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THE
FIRST PRINCIPLES
OF
FIELD-FORTIFICATION:

CONTAINING
INSTRUCTIONS FOR THE CONSTRUCTION,
ATTACK, AND DEFENCE OF

FIRST PRINCIPLES
OF
FIELD-FORTIFICATION.

TRANSLATED FROM THE GERMAN
BY
WILLIAM NICHOLAY,
MAJOR-GENERAL IN THE ARMY OF GREAT BRITAIN.

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CONCISE AND FAMILIAR PRECEPTS FOR THE CONSTRUCTION,
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FIELD-WORKS;

WITH A PRELIMINARY INTRODUCTION TO THE SCIENCE
OF FORTIFICATION IN GENERAL.

BY
CHARLES AUGUSTUS STRUENSEE.

TRANSLATED FROM THE GERMAN,
BY
WILLIAM NICOLAY,
CAPTAIN-LIEUTENANT IN THE CORPS OF ROYAL ENGINEERS.

London:

PRINTED BY BUNNEY AND GOLD, SHOE-LANE;
FOR G. AND W. NICOL, BOOKSELLERS TO HIS MAJESTY, PALL-MALL.

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1855

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 omitted a few passages which seemed either super-
ADVERTISEMENT.

THE works of Struensee form a complete Course
 of Fortification, and have received universal appro-
 bation upon the Continent. The following treatise
 is a translation of the First Part of that Course,
 which appears particularly well calculated for a
 book of instruction, and for the use of the Army in
 general; since, from the order and simplicity with
 which it is written, it is perfectly comprehensible to
 a beginner, and at the same time is sufficiently
 extensive to enable an Officer to acquire a knowledge
 of the fundamental principles, and practical part of
 Fortification in the Field.

This translation is made from an edition publish-
 ed at Copenhagen in 1797, by H. I. Krebs, Pro-
 fessor, and Captain in the Royal Artillery of Den-
 mark. The translator has endeavoured throughout
 to adhere strictly to the spirit of the original;
 but as his chief object has been to render it a work

of general utility, he conceived it necessary to make some trifling alterations. With this view he has omitted a few passages which seemed either superfluous, or mere repetitions; and as the dimensions and constructions in the original are given at different times in rods, feet, and paces, he has adapted them all to English measures, which it is presumed will tend to make the subject more simple.

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PRELIMINARY INTRODUCTION.

§ 1.

FORTIFICATION is the science which teaches the method of putting a place into an advantageous state of defence; and the proper manner of attacking and defending it*.

By a **PLACE**, or **POST**, I here comprehend every part of the surface of the earth. It may be either a town, a village, a castle, a church, a single house, a hill, a hollow way, a whole strand or shore, a bridge, or the like. Fortification first of all explains the means by which all these may be placed in security, either in a durable manner, or for a temporary purpose against the attack of an enemy; and consequently the rules of this science must be respectively applied to all these cases.

In most treatises upon fortification we are only taught the mode of fortifying a town in a perma-

* The Latin and French names for Fortification are Architectura militaris; Ars fortificatoria—Architecture militaire; l'Art de fortifier des places; La Science des Ingenieurs. **AUTHOR.**

nent manner, so as to resist the most powerful attack of an enemy; or how to erect, attack, and defend such places as may properly be termed Fortresses: but from the more extensive idea which I have given of this science, it is by no means confined to the subject of permanent works.

§ 3.

From the explication given of fortification, (§ 1), we may frequently expect that an enemy will endeavour to make himself master of the place in which we are stationed; and consequently that he will employ various means to attain his object. We must therefore be acquainted with these means in order that we may cover our post properly against them, and secure it by all possible counter preparations.

The mode of fortifying a place must naturally at all times be adapted to the existing system of attack; and every new kind of attack requires a different method of fortification.

The invention of gunpowder having caused a total change in the measures to be pursued for the conquest of a place, it became likewise necessary to adopt suitable alterations for its security; and it is therefore no wonder that the strong-holds erected in modern times differ very much from those of the ancients.

§ 4. There

§ 4.

There are at present many different ways of attacking a place. The work and garrison may be battered and bombarded; or petards employed to burst open the gates. An entrance may be obtained by means of mines; or admittance procured by artifice and a secret understanding with certain people within the place. Sometimes an open assault may be attempted; or, lastly, the garrison may be compelled to surrender for want of provisions. A fortress must be secure from all these in order to be accounted perfect, and the enemy ought to have no means left of attacking it with the prospect of success.

It is not however possible in every situation to provide against all these kinds of attack, as time and other circumstances frequently will not allow us to execute the necessary preparations: we must therefore be content with securing our post against such of them as are most to be apprehended; but should endeavour in every case to approach as near as possible to the given idea of a perfect fortress: and it may also be considered as a criterion for judging of other works, which come the nearer to perfection, the more they correspond with it.

§ 5.

An objection may here be suggested, that even the best works do not afford any defence to a gar-

rison against being starved out, surprised, or betrayed. In answer to this we must consider that to prevent being starved out, the post ought to be furnished with proper magazines, and a sufficient supply of water: that the garrison may not be surprised, it should be in high discipline, and extremely alert: and to prevent being betrayed to the enemy, the commanding officer should observe certain rules of prudence, circumspection, and attention.

Works are not indeed erected immediately to resist such kinds of attack; nevertheless by a judicious plan of a fort, together with good internal regulations, the defence must be rendered very easy to the garrison. Strong and spacious receptacles for provisions ought to be established within the works: the aqueducts should be properly covered that the enemy may not be able to cut them off: and as projects to surprise a fort, or to carry it by artifice, are generally founded on some defect attached to it, an engineer should know how to dispose of the works in such a manner, that the enemy may find innumerable difficulties in the execution of such an enterprise.

§ 6.

As the general intention in fortifying a place is to obtain an advantage in its defence, the particular object must always be, to enable a few men to defend themselves in safety against a great number who attack them; or that a small garrison may

be placed in such circumstances that it gains an equality, and even a superiority over a greater force. This may be effected in a twofold manner.

First, by making such dispositions that the troops may have nothing to fear from the fire of the enemy, whilst they, on the contrary, are enabled to make use of all their means of defence, and to fire upon him without obstruction as soon as he is within reach. Secondly, by throwing various obstacles in the enemy's way, to prevent his approaching the place. In short, we should endeavour to make such arrangements, that the enemy must find endless difficulties in all his undertakings, and the garrison none.

§ 7.

Fortification may properly be divided into two principal parts.

The first part contains instructions for fortifying posts in the field, in time of war; frequently in the greatest haste, and with few means at hand: together with the method of attacking and defending them. This is called FIELD-FORTIFICATION.

The second part explains the rules by which such places as are properly termed Fortresses, ought to be constructed so as to resist the strongest attack of an enemy, and the manner in which they should be attacked and defended. As works of this nature are intended not only for the security of a whole country against the attack or irruption of

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an enemy, but also to be durable; this is termed
PERMANENT FORTIFICATION.

§ 8.

ORIGIN OF FORTIFICATION.

Fortification is undoubtedly a very ancient science; however the first fortresses cannot be regarded as great works, or those who erected them as masters of the art. Necessity was the original cause of the employment of engineers. Their occupation was to secure themselves and their fellow-citizens from the assaults of robbers, who in the beginning did not make any considerable warlike preparations, so that there was no great difficulty in devising means to keep them off: and as the general intention of building a fortress is to enable the inhabitants to defend themselves with security and advantage against the attack of an enemy; the works of former times may be considered as good, and even perfect, although totally useless at present. History does not give any certain information concerning the nature of primary fortresses.

§ 9.

STATE OF FORTIFICATION BEFORE THE DISCOVERY OF GUNPOWDER.

Fortification received improvements from time to time, as the art of war advanced.

At first the ancients only erected walls around the places they wished to fortify. These walls were so thick that they could not be forced down by battering rams, and sufficiently high to prevent being easily scaled by means of ladders. Upon the outside of these walls others of weaker dimensions were raised, which covered the men destined for the defence, and through which openings were made for the garrison to shoot at the enemy. In order to prevent the enemy's approaching the wall, it was encompassed by a broad and deep ditch.

It was soon found that this did not afford sufficient defence to the foot of the wall, as it could not be hit from above: towers were therefore built at certain distances, projecting from the wall, which thereby obtained a flank defence. These towers were made still stronger than the wall, and were not placed further asunder than an arrow could reach. They were moreover formed with a projection at top, from whence the garrison could shoot down upon those who endeavoured to approach.

The ancients had not any notion of constructing several works in front of one another; but their fortresses were frequently surrounded by a double and even a triple wall.

§ 10.

ANCIENT METHOD OF ATTACK.

When the ancients designed to attack a fortress, they usually endeavoured to approach it under cover,

cover, carrying with them high, moveable, wooden towers, upon the top of which soldiers were stationed in order to drive the garrison from the walls by means of their bows and arrows, or other weapons. They also filled up the ditch, and strove to throw down the wall by the force of the battering ram. Sometimes they dug away the earth from under the wall, and propped it up only with timber-work, which they afterwards set on fire, and thereby occasioned the wall to fall down. As soon as an opening was by any means effected, they proceeded to the storm, forcing into the town with great violence. They likewise made use of certain machines called Catapultas and Ballistas, from which large stones, and whole volleys of arrows, were projected upon the enemy*.

§ 11.

ANCIENT METHOD OF DEFENCE.

The ancients defended themselves at all times with the greatest valour. They employed all their might to prevent the enemy's advancing with his warlike machines; and endeavoured to render the passage across the ditch extremely difficult. They threw large stones from their Catapultas, upon the towers of the enemy, in order to crush them; and undermined them in the same

* See Folard's *Traité de l'Attaque, & de la Défense des Places des Anciens*. **AUTHOR.**

manner as the besiegers did the wall of the fortress. They sallied out, and strove to set fire to the enemy's towers and other machines: and when at length a breach was made in the wall, they resisted the storm, and defended themselves in the streets of the town in the most strenuous manner. Frequently the assailants did not carry the fortress until the town was completely desolated, and all its inhabitants killed.

§ 12.

STATE OF FORTIFICATION SINCE THE DISCOVERY OF GUNPOWDER.

Upon the discovery of gunpowder, the moveable towers and battering rams above mentioned were laid aside, and cannon was introduced in the attack of places. The besieged were therefore likewise obliged to make use of artillery in the defence, and consequently the former kind of wall was not sufficiently broad.

The Spanish and Italian engineers began by constructing a rampart of earth behind the wall, wide enough to contain cannon, from which the enemy might be fired upon at a distance. It likewise became necessary to remove the small wall which hitherto served to shelter the garrison, and erect a covering of earth in lieu thereof; or at least to strengthen the wall by throwing earth against it, to prevent the injury the garrison might

do

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receive

receive from the splinters of stone struck off by the enemy's shot.

As it was afterwards perceived that the exterior side of the towers had still no good flank defence, their position was changed, and they were placed running out in an angle towards the country; and were also made sufficiently large and spacious for the use of artillery. They then received the appellation of BASTIONS.

These bastions were placed much further asunder than the towers of the ancients, the range of a cannon shot being much more extensive than that of an arrow.

The figure and disposition of the bastions frequently received some alterations, according to the principles of engineers at various periods, who endeavoured to strengthen the mode of fortification by several improvements of the bastion and rampart; as also by adding certain works on the outside of the ditch.

§ 13.

The Spanish and Italian fortresses were however only vast masses of stone put together with a great expence, but were still very defective with regard to the object proposed.

The first improvement originated with the Dutch, during the war they carried on in maintenance of their freedom against the Spaniards. It is true they had neither sufficient time nor money to erect such

such costly fortresses of masonry; but although they constructed their works merely of earth, they proceeded on much better grounds with respect to the design, as afterwards appeared; and advanced with considerable steps towards the true principles of fortification.

These engineers indeed frequently committed great and ridiculous errors; but the Dutch were successful in their war against the Spaniards; and the consequence was, that their fortresses and engineers acquired such reputation, that every nation which required them had recourse to Holland.

§14.

When the defects of the Dutch fortresses were afterwards observed, and it was found that they actually made bad defences in the war which Louis the XIVth began against the Dutch, in the year 1672; several skilful German, French, and Dutch engineers, towards the close of the former and beginning of the present century, strove to establish the true principles of fortification; and rivalled one another in their endeavours to bring the art of fortifying places, and of attacking and defending them, continually nearer to perfection. I might here discuss fully the merit and inventions of Count Pagan, Marshal Vauban, Coehorn, Reimplers, and other great engineers: but as this would in general be unintelligible to a beginner, I will rather defer

it until it becomes necessary to notice their several discoveries.

§ 15.

In modern times likewise several able engineers have contributed much to the alteration and improvement of former systems; and amongst them we are particularly indebted to Belidor for some very happy discoveries. Nevertheless the systems of those engineers first mentioned have been hitherto most generally received, at least in practice; and it is still doubtful whether any projects more modern, which require a total change in fortification, ought to be followed.

§ 16.

UTILITY OF FORTIFICATION.

Although it is not necessary here to enter into an extensive enquiry as to the utility of the science of fortification, nevertheless as some people have been of opinion that fortresses are more prejudicial than serviceable to a nation, I will briefly shew that they always procure great and important advantages to an army in time of war.

An army during a campaign requires various and innumerable articles, both for its maintenance and the execution of the project, but it can only carry such of them along with it, as are immediately

ately necessary: if therefore the rest are left behind in an open unprotected spot, an enemy might easily surprise such a place of arms, and carry off the magazines, or at least destroy them: and if to prevent this a great detachment is left as a security for the post, the army would thereby become too weak: whereas in a fortified place these magazines might be easily protected by a small garrison.

§ 17.

These principles are universal, and hold good whether an army acts offensively or defensively. In the former case it cannot pursue its conquests securely and speedily unless it possesses strong posts, from which it may be supplied from time to time with necessaries. Moreover, without this resource, the army might probably on the smallest misfortune, be obliged to abandon its conquests with greater haste than it acquired them, and even run great hazard of being totally dispersed or annihilated. We have several examples of this in history.

§ 18.

Fortresses are still more necessary to an army engaged in a defensive war. Good posts on the frontiers are always a great protection against an unexpected attack of an enemy; and even should our army be defeated, it may retire under the cannon of a fort to recover itself, and receive fresh succours.

succours. As the enemy cannot penetrate further into our country without first gaining possession of the fortified places on his route, his progress in pursuit of our army would thereby be checked, and he would lose so much time in besieging these places, that he might not be able to gain more ground during the whole campaign.

If we are liable to be attacked by a superior force, and on more sides than one, our fortresses afford us great opportunity of sending speedy assistance to that quarter the most in need*.

The late war which the King of Prussia carried on against the allied powers gives an incontestible proof of the utility of fortresses.

§ 19.

There are indeed, apparently, many objections to be made against the utility of fortresses. It may be urged that when the enemy has taken them, they become highly injurious to us, and that it would be much better if we had never possessed any such places; but this is in fact an acknowledgment of the advantage they confer on those who hold them.

It may further be objected, that, in order to furnish sufficient garrisons for our fortresses, the

* Although the reasons here given for the establishment of permanent frontier posts may not be applicable to our insular situation; they are highly so to our continental possessions in America and India. TRANSLATOR.

army becomes too much reduced. Too great a number of fortified places are undoubtedly detrimental; but it does not follow that such places in general are useless. An army which is not sufficiently strong to furnish garrisons for the places of arms, and other posts indispensable for its security, must be regarded as too weak for the purpose of war in general; as it is absolutely necessary, in order to carry on a war, to have an army, fortresses, money, provisions, artillery, ammunition, and innumerable other things. All these articles are needful in themselves, and frequently the want of any one of them cannot be supplied by the joint assistance of all the others.

Lastly, examples may be produced of countries which have been conquered, though well provided with fortresses; and on the contrary, of others which have maintained their ground without any.

Fortifications undoubtedly are not an infallible means, or the only one by which a nation may defend itself against an enemy; but it is certain that a country totally destitute of such places, cannot be so easily defended, and must fall sooner than one which contains posts well fortified. Had Poland lately possessed good fortresses, and a standing army with its necessary appointments, the fate of that kingdom could scarcely have proved so miserable.

There are not indeed any fortifications in England; but it must be remembered that it is an Island, which prevents an enemy's landing, by means

means of its mighty fleets; but should an enemy's army actually land in England, that country would undoubtedly be conquered more easily than the Netherlands.

Switzerland likewise has no fortresses; but nature has so well provided for the security of that country, that all artificial defence is rendered superfluous.

§ 20.

If it is admitted that good fortresses are in most cases beneficial to a nation, it must necessarily follow that fortification is a useful science.

An engineer in particular ought to be acquainted with it in its utmost extent, and understand it thoroughly; but a knowledge of this science is likewise useful, and in many cases absolutely necessary for every other officer who looks forward to the attainment of the higher military dignities.

Every officer ought to consider that the command of a fortified place may devolve upon him: if then he is totally unacquainted with fortification, he must continually refer to the engineer. By this means he becomes, in fact, only the second in the place, and acts as the other requires; whilst all the responsibility falls on him, and the honour of the defence is attributed entirely to the engineer.

Again, when an officer is entrusted with the siege of a fortress, it would surely redound much to

to his honour to be acquainted with the rules by which a place ought to be attacked, and to be capable of examining and judging of every thing proposed by the engineer.

Lastly, when an officer has the direction of a whole army, which he wishes to place in a state of security, by the various means of defence; it would evidently be better that the general should understand the subject, than that every thing should be regulated merely according to the opinion of the engineer.

§ 21.

Fortification is serviceable even to an inferior officer. All parts of this science indeed are not of equal importance to him; and it may be sufficient if he understands field-fortification only, and has such general ideas of permanent fortresses, as may enable him the better to comprehend the nature of attack and defence.

Every officer may be placed in a situation where he must arrange measures for the security and defence of a small post: he may have to defend himself in a village, a church, a small town, or the like; he may have the superintendence of workmen employed under the direction of the engineers; or many other cases of the kind. How is it possible for an officer to discharge these duties without some knowledge of field-fortification?

An officer placed over workmen during a siege, has many opportunities of reaping the fruits of his
D
acquired

acquired knowledge; and, on the contrary, the whole siege must be very much retarded, if upon the smallest occurrence, reference must be made to an engineer, owing to the want of other officers acquainted with the subject.

This is equally applicable to the defence of a besieged place; which would undoubtedly hold out the longer, if the garrison contained several officers versed in the rules of defence.

An officer of infantry should endeavour the more to acquire a fundamental knowledge of fortification, as cases, similar to those quoted above, are almost the only situations where an inferior officer can distinguish himself, and attract the notice of his superiors. If an officer makes a good defence of a bad post, or gives proofs of his knowledge during a siege, or the defence of a fortress, his abilities must be observed; and may be the means of procuring him most important rewards.

FIRST PRINCIPLES

OF

FIELD-FORTIFICATION.

PART I.

OF THE NATURE AND CONSTRUCTION OF
FIELD-WORKS.

CHAPTER I.

OF THE BREASTWORK.

§ 22.

DEFINITION.

THE garrison of a fortified place should be secured against every attack of an enemy, and ought especially to have nothing to apprehend from the fire of his artillery and musketry. For this purpose an elevation is thrown up around the place, to conceal the garrison; and which at the same time is so strong that the enemy's shot cannot pierce through it. This elevation is called a **BREASTWORK** *.

* The terms *breastwork* and *parapet* are frequently made use of indiscriminately; but I conceive the former to be most proper here in a general sense; a parapet implying more immediately that breastwork which is raised upon the rampart of a permanent fortress. TRANSLATOR.

MATERIALS OF THE BREASTWORK.

A breastwork is usually formed simply of earth; not only as being easily procured almost every where, and with the least expence, but also on account of many objections and difficulties which occur in the use of other materials. If the breastwork was made of stone or wood, the garrison would be liable to have more men killed and wounded by the splinters struck off by the enemy, than by his shot.

The stiffer the earth, the better it is for the formation of a breastwork; partly because a stiff earth adheres well together, and partly because it destroys the force of the balls which penetrate it, better than any other. A soil of loam or clay is therefore to be preferred to all other kinds of earth for this purpose.

If there is no earth at hand—nothing to fear from the enemy's cannon—or in situations where we are under the necessity of fortifying ourselves in a speedy manner, to prevent an enemy's breaking in; this rule of employing earth for the breastwork may be deviated from. Thus in rocky or marshy ground, a covering may be formed of woolsacks, dung, brushwood bound together, or fascines.

Works may also be found where the garrison has no other covering than a wall, because the enemy cannot

cannot bring any cannon against it. Cases of this kind however by no means do away the general maxim; and earth must in most situations be looked upon as the material of which a breastwork is to be formed.

§ 25.

HEIGHT OF THE BREASTWORK.

A breastwork should be of such a height that a soldier standing behind it cannot be seen by the enemy.

If therefore the garrison and the enemy are on the same level, a height of six feet is sufficient to cover the garrison; but if the enemy is on higher ground than the garrison, a man behind a breastwork six feet high, on removing a few paces from it, would no longer be covered by it. In this case something must be added to the height of the breastwork; and the principles of geometry will easily determine how much it must be augmented in each particular case, according to the distance of the enemy from the breastwork; the space behind it in which the garrison is to be covered; and the height of the ground on which the enemy is posted.

For example, let cd (Pl. 1. fig. 1.) be the height of the enemy; bc his distance from the breastwork; ab the space where the garrison is to be covered; and ae the height of a soldier, or six feet. Join the points d , e , and draw eh parallel to

to $a c$. Now if at b , a perpendicular $b f$ be erected, then will $b f$ be the required height of the breastwork, and $f g$ the excess of that height above six feet.

The height of the breastwork may also be found in the following manner. Let a man place himself at that distance behind it, where it is intended the garrison shall be covered. The work must then be carried up to such a height, that he can no longer see a person standing upon the ground which it may be imagined an enemy will occupy; and of course the enemy can neither see nor hit him from that spot.

Lastly, if the garrison stands on higher ground than the enemy, the breastwork need not even be six feet high; and the more the garrison is elevated, the lower the work may be. It is here also easy to determine the necessary height in every case, by only considering the intention of the breastwork; which is at all times to shelter the soldiers placed behind it, from the fire of the enemy's cannon and small arms.

§ 26.

THICKNESS OF THE BREASTWORK.

A breastwork should be so strong that the enemy's shot cannot penetrate entirely through it, and hurt the soldiers behind it. The largest cannon now used in the field are 24 pounders; and when these are fired with a charge of from 8 to 12 lbs. of powder,

powder, experience teaches us that a 24lb. shot will penetrate 15 feet into good earth, and from 18 to 20 into a bad soil. In order therefore that a breastwork may resist the most powerful attack, it must have a thickness of at least 18 feet in the former case, and from 22 to 24 feet in the latter.

It is not however customary to give a breastwork this considerable thickness, except in actual fortresses. In works thrown up in the field, frequently in the greatest haste, and where we expect to be attacked only by field-pieces, a thickness of from 10 to 12 feet is perfectly sufficient.

Lastly, if a breastwork is intended to hold out only against musketry; or if it is erected with no other design than to prevent the enemy's seeing the troops behind it, it will be enough if it is from 3 to 6 feet thick.

§ 27.

SLOPE OF THE BREASTWORK.

If a breastwork is to be formed of earth, neither its inner nor its outer side can be carried up perpendicular to the horizon; but each side must make an acute angle with the horizontal base of the work, otherwise it would soon fall down. These oblique surfaces are called the **INTERIOR AND EXTERIOR SLOPE OR TALUS OF THE BREASTWORK.**

The profile or section of a breastwork will be a four-sided figure as $abcd$ (Pl. 1. fig. 2.) where ad is

is the profile of the interior, and bc of the exterior slope; ab is the upper thickness, and dc the lower thickness of the breastwork; and if from the points a and b the perpendiculars ae , bf , be drawn, then will de be the base of the interior, and fc the base of the exterior slope.

§ 28.

SIZE OF THE SLOPE IN GENERAL.

The size of the slope depends upon the angles x and y . The greater the former and the less the latter, the larger the slope will be. But both these angles are determined by the proportion of the lines ae , de to one another: for as long as these lines preserve the same proportion, the angles will also remain the same; but as soon as that proportion is altered, the angles will vary likewise. If de becomes greater whilst ae keeps the same length, the angle x will be augmented and y diminished: on the contrary, if ae increases and de remains as before, the angle y will increase also, and x decrease. Now as ae is the height of the breastwork, and de the base of the slope, the principle is easily perceived upon which engineers, when they wish to determine the size of the slope, are accustomed only to assign the proportion which its base should bear to the height of the work.

§ 29. Since

loose earth, we must have recourse to some other

§ 29. Since the side of a breastwork is formed with a slope, to prevent its falling down, and as good earth will more easily stand firm, than that which is bad; it follows that in a clayey or good soil, the base of the slope need not be so large as in a sandy or bad ground.

It is found by experience that earth which is good will stand when the base of the slope is only equal to half the height, but that bad earth requires a slope equal to the whole height: therefore when other reasons do not render it necessary to vary from this rule, it may be looked upon for earth-work in general, that if the soil is very good, the base should be equal to half the height; if middling, to two-third's the height; and if it is very bad, the base must be equal to the height.

§ 30.

OF THE INTERIOR SLOPE.

As it is necessary that the soldiers who stand and fire behind a breastwork should be as close to it as circumstances will admit, we should endeavour to keep the interior slope as small as possible. For this reason it is usual to make the base only one-sixth of the height: but it will seldom stand with this base, even though the soil is particularly good, and where every possible attention has been given to the formation of the work. In lieu therefore of

loose earth, we must have recourse to some other materials in order to retain the interior side of the breastwork, and prevent its falling; and whatever is made use of for that purpose is called a **REVETEMENT**.

For the revetement we may employ either fascines, hurdles, sods, a lining of boards, or even a stone wall. Of these, the most advantageous in the field are fascines, or hurdles made of willow twigs wattled together in the manner of basket-work. The materials of which they are made are easily obtained every where, and the interior side of a breastwork may by this means be run up in a very short time: but as neither fascines nor hurdles are durable, they should never be used in any work which is intended to last long.

In a permanent fortress, the inner side of the parapet should be formed of sods; an interior revetement of boards or stone not being proper either in the field, or in permanent works. In the field a revetement of this nature would require too much time, and is always very detrimental to the garrison, which might suffer considerably from the splinters, as hath been already observed. Moreover boards soon become rotten, and a slope constructed of them would cause great expence to maintain it.

§ 31.

OF THE EXTERIOR SLOPE.

The exterior slope of a breastwork being exposed to the fire of the enemy, is more liable to fall down than the interior side, and must therefore have a larger base, but the smaller this base is kept, the more difficult it is for an enemy to climb it; and for this reason alone it ought always to be as narrow as the nature of the soil will allow. If we wish to retain the exterior slope by a revetement, the rules given (§ 30.) for the interior slope extend to this likewise; except that boards or stone would not here be so dangerous to the garrison: nevertheless all stone revetements should be rejected in field-works, on account of the preparations attending them.

§ 32.

OF THE BANQUETTE.

The profile of a breastwork formed according to the above rules will have nearly the appearance of fig. 3. The soldiers behind such a work are entirely sheltered from the enemy's cannon and musketry: but in order that they may be enabled to fire on the enemy without obstruction, an elevation of earth is made immediately behind it, which the soldiers mount when they are to fire. This elevation is called a BANQUETTE, and should be raised

until the height of the breastwork above it, is about four feet two inches. A man standing upon such a banquette, can make use of his arms properly, and fire conveniently over the breastwork.

If the height of the breastwork is six feet, that of the banquette will accordingly be one foot ten inches; and if the breastwork is higher, the banquette must also be raised. To render the ascent perfectly easy its slope should be very broad; at least equal to, or even double its height.

The breadth of the banquette should be three feet or more, according to the number of ranks in which the men are drawn up.

In fig. 4, *dghk* represents a banquette and slope, constructed agreeable to the rules given above.

§ 33.

OF THE SUMMIT, OR CROWN OF THE BREASTWORK.

The upper surface of the breastwork, called the **SUMMIT** or **CROWN**, has hitherto been supposed parallel to the horizon; but it must be made with a declivity towards the country; otherwise it is evident that when the enemy is advanced within a moderate distance of the work, he cannot be hit from behind it; whereas by giving the top a slope, he can be seen when very near.

The

The difference of height between the interior and exterior slopes depends principally upon the thickness of the work. If this is about 24 feet, the exterior slope may be two feet lower than the interior; but if the breastwork is weaker, the difference of these heights must be proportionably smaller.

I here suppose the work to stand upon level ground; but if on the contrary it is on an eminence, it may probably become necessary to give the superior slope a greater declivity, that the enemy may be discovered in his ascent.

The proper inclination of this slope may always be easily determined, only taking care that the fire regulated by it, is not confined to a single point on the neighbouring ground, but extends as much as possible*.

The fifth fig. represents a breastwork, the crown of which is made sloping towards the enemy, according to the above principles.

* The necessity of giving the summit of the breastwork an inclination is universally allowed; but as it can scarcely be expected that troops, who in firing are accustomed to a certain level, will observe the direction of this slope, especially by night; the advantage proposed by it is lost, unless some easy method can be adopted, by which this direction may be preserved.

Perhaps this might be effected in some situations by raising part of the breastwork, towards the inside, higher than the rest. The soldier might lay his piece upon the part thus raised, which being formed with the proper slope, he must necessarily fire in the true line. By this means also he would, at least in idea, be better covered, and less exposed in firing. TRANSLATOR.

§ 34.

OF THE GLACIS.

A breastwork which has no exterior slope, but its summit continued outwards, until it meets the surface of the ground, is called a GLACIS. The base of a glacis must always be much broader than that of a common breastwork; for if it did not exceed 18 or 24 feet, the work would be too weak, and moreover its slope would be so steep that the fire acting in that direction, instead of grazing, would only bury itself in the ground. It is therefore usual to make the glacis from 25 to 50 yards wide. The profile of a glacis is shewn in fig. 6.

A double advantage is derived from the glacis. First, every point in front of it is exposed to be struck from the small arms of the garrison behind it; whereas in a breastwork, the whole triangular space bcm (fig. 5.) is secure from it. The second advantage is, that it cannot be destroyed by the enemy's shot, which only strike into it, the loose earth occasioned thereby remaining in its proper place.

The glacis however is attended with this disadvantage, that the enemy can mount it without any difficulty.

OF THE USE OF CANNON BEHIND A BREAST WORK.

Having shewn that soldiers can be posted under cover behind a breastwork, and make use of their arms without obstruction; I will now proceed to explain how artillery may likewise be employed against an enemy. This may be accomplished by two different methods.

In the first place, instead of a banquette behind a work, an elevation of earth is formed sufficiently large to contain guns mounted on their carriages, and of such a height that their muzzles may reach above the summit of the breastwork.

This is termed a battery *EN BARBETTE*.

The height to which the earth must be raised for this purpose depends upon the nature of the gun, and the height of the breastwork: in general it must be carried up to within two and a half or three feet of the top of the work. Its breadth should be sufficient to afford convenient room for the gun, and men attached to it; therefore about 10 or 12 feet are allowed for each piece of cannon. Its length ought to be from 12 to 18 feet, according to the nature of the gun, that there may be sufficient space behind to prevent its running down in the recoil. Lastly, an easy slope, called a *RAMP*, is made to every battery of this nature, in order that the guns may be run up without difficulty.

In

In fig. 7, *bcih* is the section of such a work, and *aib* the ramp. The plan is shewn in fig. 8.

§ 36.

The foregoing method is in many respects convenient, and has several advantages; nevertheless the guns and men who serve them are so much exposed to the enemy's fire, that it ought properly to be adopted only,

1. When we know the enemy to be so situated that he cannot bring artillery to bear against us. Thus for example; guns en barbette are with great propriety made use of in a fortress, until such time as the besiegers have established their batteries against it.
2. When we are posted upon an eminence, and that there is not a single spot in the neighbouring country, from which the enemy can fire upon us in a horizontal direction.

There are indeed other situations where guns may be fired in this manner; but we should then endeavour at least to cover the artillery-men by means of gabions, or sand-bags placed upon the breastwork, leaving an opening of a foot and a half or 2 feet between them, for the mouth of the cannon; and if two or more rows of gabions are placed before one another, the opening must increase in width towards the front; that we may be enabled to point the gun to either side, as well as directly forwards. See fig. 8.

§ 37. Cannon

Cannon may also be made use of behind a breastwork, by means of openings cut through it, called **EMBRASURES**. The two sides of an embrasure are termed the **CHEEKS**, and that part of the breastwork between the bottom of the embrasure and the ground upon which the gun stands, is named **THE GENOUILLIERE**, or **SOLE**. An embrasure is always broader in front than behind, that the gun may be laid in various directions. Its breadth is a foot and a half or two feet within, and from five to eight feet without. The bottom is usually made sloping downwards, in a direction nearly parallel to the summit of the breastwork. The cheeks have likewise a very small slope, and are retained in the same manner as the interior slope of the breastwork (§ 30.); that is, in the field by means of fascines or hurdles, and in permanent fortresses by sodwork.—Fig. 9 represents the profile, and fig. 10 the plan of an embrasure.

When several pieces of cannon are to be placed adjacent to one another behind a work, their distance asunder should be from 12 to 20 feet. If embrasures are cut for these guns, a piece of the breastwork will remain standing between every two: this is called by engineers a **MERLON**, and is represented by *d c f e* (fig. 10.)

As it is to be expected that the enemy will direct his fire principally against our batteries, the merlons ought to be very strong, and should be constructed

constructed with great attention; and as it is not intended to make use of musketry behind them, they may, for the better security of the gunners, be made eight or nine feet high.

§ 38.

OF THE DITCH.

In order to procure the earth requisite for the formation of a breastwork, it is customary to make a ditch on the outside of it; by which we also obtain another advantage, as the enemy has an additional obstacle to overcome in his attempts to approach us.

There are however situations where the ditch is behind the work. For example, if an intrenchment is formed upon a very steep hill, a ditch in front of the work would not render the enemy's endeavours to climb it more difficult; and as it is much more convenient in such cases to make use of the earth within the breastwork, it may be done without any disadvantage. The same method is pursued in conducting the trenches towards a fortified place, by which means the besiegers are the sooner under cover from the fire of the garrison.

§ 39.

The ditch must be made sloping on both sides: the inner slope is called the **SCARP**, and the outer slope the **COUNTERSCARP**. The width of their bases,

bases, like that of the exterior slope of the breastwork (§ 31.) is determined by the nature of the soil; but to cause the enemy as much trouble as possible in getting in and out of the ditch, these slopes ought to be as steep as the tenacity of the ground will allow.

§ 40.

OF THE BERME.

When the exterior slope of the breastwork, and the interior slope of the ditch form one continued surface (fig. 11.) the enemy has the greatest difficulty in gaining the top of the work; but the scarp in this case has too great a pressure to sustain; it must consequently soon give way, and a considerable part of the work would fall with it. Even if the scarp should stand firm, the earth must constantly fall from the breastwork into the ditch, and fill it up to our great disadvantage. To prevent this, the breastwork is thrown up at a small distance from the edge of the ditch, thereby leaving a free passage between them, called a BERME. This is shewn by fn (fig. 12.)

The berme undoubtedly facilitates the enemy's mounting the breastwork: in order therefore to diminish the advantage he may derive from it, it ought to be as narrow as possible; and we must have recourse to other obstacles, of which I shall treat hereafter.

§ 41.

SIZE OF THE DITCH.

The size of the ditch is generally regulated by that of the breastwork. The quantity of earth requisite for the work may be procured equally whether the ditch is wide and shallow, or narrow and deep; but the removing it is more easily performed by the latter mode; and the enemy will also have the greater difficulty in getting in and out of the ditch. In low situations however, this cannot always be done; and the ditch must at all times be sufficiently broad to prevent an enemy's leaping across it.

It is usual to make the ditch about 10 or 12 feet wide, and wherever the situation allows, at least six feet deep; but if those dimensions will not furnish the necessary quantity of earth for the breastwork, an augmentation must be made either to the width, or depth, and sometimes to both.

§ 42.

As it is necessary in every case first to ascertain the breadth and depth of the ditch, I will here explain the method of finding those dimensions according to the nature of the breastwork, by a geometrical calculation. When the direction of the work is a right line, as hath hitherto been supposed, it is evident that the length of the ditch will

will be exactly equal to that of the work; and consequently both these lengths may be rejected; so that the respective profiles only of the breastwork and ditch are to be taken into consideration, and the area of these must be equal to one another.

The superficial content of the profile of the breastwork must be found first, which will also be the area of the section of the ditch: but this latter area may be regarded likewise as the product of the breadth multiplied by the depth: therefore if we assume one of these dimensions so as to suit the purpose, for example the depth, and divide the area of the section by it, the quotient will give the breadth. But as the ditch is broader at top than at bottom, (§ 39.) the breadth thus found is properly only an arithmetical mean proportional between the upper and lower breadths, and is called **THE MEAN BREADTH OF THE DITCH**. If half the sum of the bases of the interior and exterior slopes, or when these are equal, if the whole base of one of the slopes be added to the mean breadth, it will give the upper width of the ditch; and by subtracting the same quantity from it, the width of the bottom is found. The justness of the above proceeding is evident on inspecting the 11th fig.

If this calculation should not give a competent breadth for the ditch, the assumed depth must be altered, until one dimension can be commodiously regulated by the other.

§ 43. The

The foregoing rule will be more clearly illustrated by the following example:

Calculation of the profile (fig. 12.)

The area of

$$akb = ak \times \frac{1}{2}bh = 3 \times 1 = 3$$

$$kicb = ki \times ic = 3 \times 2 = 6$$

$$ibdc = \frac{ic + db}{2} \times \frac{1}{2}ib = 8 \times \frac{1}{2} = 4$$

$$bgcd = \frac{bd + ge}{2} \times \frac{1}{2}hg = 10 \times 6 = 60$$

$$gfe = gf \times \frac{1}{2}ge = 2 \times 2 = 4$$

The sum of all these = 77 square feet, is the area of the whole profile.

Now if for the depth of the ditch we assume 8 feet, the mean breadth will be $77 \div 8 = 9\frac{1}{2}$, or nearly $9\frac{1}{2}$ feet: and if the base of each slope is 4 feet,

the upper breadth of the ditch will be $9\frac{1}{2} + 4 = 13\frac{1}{2}$ feet,

and the lower ditto $9\frac{1}{2} - 4 = 5\frac{1}{2}$ feet.

§ 44.

REMARK.

When the earth made use of in the construction of a breastwork is of a compact nature, it is scarcely possible to ram it together into so firm a state as it naturally occupied; and for this reason the quantity excavated from the ditch agreeable to the above rule, will be too great, notwithstanding the calculation may be correct. This circumstance however is of no importance, for when it is discovered in the process of the work, that sufficient earth is obtained, the ditch need not be continued any deeper; or the superfluous earth may be thrown upon the counterscarp, and there spread out in form of a glacis, as ghk (fig. 11.) By the

the latter method we gain the advantage of a deeper ditch, and the enemy standing at the point h is likewise more exposed to the fire of our musketry, than at g . At the same time we should be cautious that this glacis is not too much raised; for if it was carried up higher than h , it would impede the fire of the garrison in the direction $c d h$.

If on the other hand, owing to the soil being light or marshy, the quantity of earth excavated from the ditch according to the foregoing rule, proves too small; the deficiency may be supplied by increasing the dimensions of the ditch*.

* In the original treatise here follows an explanation of various methods of representing a breastwork upon paper. I have omitted that part, as it is rather foreign to the general design of this work; particularly as the author says, that to practise those instructions, it is necessary to have a knowledge of geometry, and the art of drawing in water colours. TRANSLATOR.

CHAPTER II.

OF THE MEANS OF OBSTRUCTING THE ENEMY'S ACCESS TO
THE BREASTWORK.

§ 45.

DEFECTS OF THE BREASTWORK.

A BREASTWORK constructed according to the foregoing rules, covers our garrison against the fire of the enemy; and on the contrary we are enabled to fire upon him with tolerable security, during his march towards it. Notwithstanding this, if he is resolute, the loss of a few men will not deter him from prosecuting his attack; and as there is no particular difficulty in getting over the ditch, and climbing the work, we have ultimately no superiority over him. But if we can likewise impede his crossing the ditch, and mounting the breastwork, it must tend greatly to the advantage of the garrison. I will now therefore examine the several means which may be practised for this purpose, and quote as many as I am acquainted with. From these, a selection suitable to each particular case may be made, and applied together with such others, as can be procured and carried into effect in the most easy manner.

It is likewise easy for the enemy at a distance to knock them down by § 46.

NATURAL OBSTACLES.

In the first place, there are certain natural obstacles which frequently render the access to a place extremely difficult: therefore when circumstances permit, we should erect our breastwork in a situation where it would be covered by some such natural obstacle: for example, behind a river, a canal, or a morass. In these cases the garrison is not only sheltered from the fire of the enemy, by means of the breastwork; but is also inaccessible on account of the water or morass. It must of course be understood that the water designed to keep off the enemy, ought to be sufficiently deep to prevent his wading through it.

A high and steep hill is likewise a very advantageous situation for a breastwork. There are many hills and rocks which can scarcely be climbed by a single person; still less by a whole body of men, who must necessarily march in a certain order.

An enemy cannot possibly approach a work erected on an eminence of this nature: nor is it necessary, either in this or the foregoing cases, to pay any great attention to the construction of it; and it is indifferent whether there is a ditch before it or not. Provided the breastwork covers the garrison from the enemy's fire, it may in this situation be considered as perfect.

§ 47.

ARTIFICIAL OBSTACLES.—PALISADES.

When natural obstacles do not present themselves, artificial means must be thought of to impede the enemy in his attempts to climb the breastwork. This may be done first of all, by PALISADES, which are stakes of wood from eight to twelve feet long, and four or five inches thick; having one end pointed, and the other fixed into the ground; and are placed so close to one another, that a man cannot pass between them. Palisades should be inserted at least two feet into the earth; and to render them still firmer, a whole row is connected by a lathe, to which each single palisade is nailed*.

Although the nature of the wood of which palisades are made, is by no means indifferent; yet in the field, whatever is most easily procured, must be made use of.

§ 48.

POSITION OF THE PALISADES.

First, palisades may be placed in the open field, in front of the ditch (Pl. 2, fig. 1, *a*); but in this situation they obstruct the fire of the garrison; and the enemy when close to them, is in great measure covered from the fire of our small arms.

* This lathe is commonly termed a *ribband*. TRANSLATOR.

It is likewise easy for the enemy at a distance to knock them down by means of his cannon; or for his carpenters to cut them down when he is sufficiently advanced. This defect may in some degree be remedied by sinking them obliquely, so that their points may be elevated only three or four feet above the ground (fig. 1, *b*). In this position however, they are still as much exposed to the fire of the enemy's artillery, as those which stand upright; and ought therefore never to be thus placed, except in situations where there is nothing to apprehend from cannon.

These oblique palisades must be bound together like the former kind, by a lathe; and should also be laid upon a strong sill, *c*, at the ground, and nailed to it.

§ 49.

Palisades are situated much better within the ditch; as being entirely secure from the enemy's artillery, and yet of the same advantage.

When the ditch is very narrow, they are usually placed in the middle of it; either upright (fig. 1, *f*); or which is better, a little oblique (fig. 2, *a*), as the enemy cannot so easily cut them down; and they are sunk in such a manner, that their points do not reach at most above a foot higher than the counterscarp.

When the ditch is something broader, the best position for palisades is either upright, directly at the foot of the counterscarp (fig. 1, *d*); or about

two feet from the outer edge of the ditch, and in a direction parallel to the slope (fig. 2, *b*). In either of these positions, the enemy cannot leap over the palisades into the ditch, without being hurt, or even impaled; and he would find great difficulty in removing them. Even though he should advance as far as the outer brink of the ditch, he would there be stopped by the palisades; and must to his great disadvantage, remain for a considerable time exposed to the whole fire of the garrison.

Finally, when the breadth of the ditch is very great, and that there is an abundance of palisades, and sufficient time, two rows may with great propriety be fixed within the ditch (fig. 3, *a, b*). It is evident that an enemy must find great difficulty in crossing such a ditch.

§ 50.

Several engineers place the palisades along the top of the berme (fig. 1, *g*.), to prevent the enemy's mounting it from the ditch; but this object can be more effectually accomplished in another manner, which will shortly be shewn: and as the palisades in this situation, are very much exposed to the fire of the enemy's artillery, it is by no means adviseable.

It is much more advantageous to place them behind the breastwork, upright upon the banquette (fig. 2, *c*), which must then be about a foot broader than usual, to allow sufficient space for the

the troops to stand. The points of these palisades reach about six inches above the summit of the breastwork; and the cross lathe to which they are nailed, may serve for the soldier to rest his piece upon, when he is to fire. Even though the enemy should have scaled the breastwork, the palisades in this position prevent his leaping down into the interior space of the work; which must tend very much to strengthen the confidence of the garrison; as it would remove those apprehensions, which might otherwise be the consequence of seeing the enemy so far advanced.

In objection to this position of the palisades, it may undoubtedly be alledged, that the enemy has no difficulty in gaining the crown of the breastwork; but this may be remedied by fixing another row within the ditch: and at all events, where there is not a ditch before the work, the best place for palisades is upon the banquette

§ 51.

A SECOND OBSTACLE.—FRAISES.

FRAISES properly speaking, are nothing more than palisades buried in the exterior slope of the breastwork (Pl. 2, fig. 3.) To prevent their being singly torn out by the enemy, they are laid upon a strong beam in the middle at *g*, and fastened to it by means of nails; and they are further secured behind, by another such beam *h*, which is placed over them, and to which they likewise are nailed.

They

They are fixed three or four feet deep into the earth; and if there is a berm, that part of the fraises which remains on the outside, must be sufficiently long to allow their points to project two or three feet in front of the scarp.

There are three directions in which fraises may be fixed into the breastwork. 1. In a horizontal position (fig. 3, *b*).—2. With the point higher than the hinder extremity (fig. 3, *d*)—or 3. With the point inclining a little downwards (fig. 3, *f*). The last of these is to be preferred, as the fraises are thereby least liable to be cut down; and should grenades or fire balls fall upon them, they must roll off again. Moreover the rain water cannot lodge upon them, but must run off into the ditch; and they are therefore likewise the most durable.

Fraises may be applied with peculiar advantage to a breastwork where there is also a row of palisades upon the banquette; the enemy would thereby meet with very great obstruction in his endeavours to climb the breastwork; as well as in his further advance in general.

§ 52. A THIRD OBSTACLE.—CHEVAUX-DE-FRISE.

A CHEVAL-DE-FRISE is a machine, consisting of a square beam of wood, about 10 or 12 feet long, and six inches thick; through which, at intervals of about six inches, stakes are inserted in form of

a cross: these stakes are from four to six feet long, and three inches thick; and have both extremities pointed, and capped with iron.

Chevaux-de-frise may be employed as another means of keeping off the enemy. For this purpose several of them are fastened together by an iron chain, and may be placed,

1. Immediately upon the counterscarp of the ditch (Pl. 2, fig. 4, *a*), or on the berme (fig. 4, *b*); but in both these situations they are subject to be easily destroyed by the enemy's artillery; and ought therefore never to be thus placed, except where there is nothing to fear from cannon. It is much better to fix them

2. Within the ditch (fig. 4, *c*); in which position they render the passage across it extremely difficult; especially if they stand behind a row of palisades.

§ 53.

A FOURTH OBSTACLE.—AN ABATTIS.

Another method of opposing the enemy's access to our breastwork, is by AN ABATTIS; which is composed of a number of trees cut down, and arranged on the outside of the ditch along the whole front of the work: they are placed close together, and upon one another; and are so disposed that their branches are presented towards the enemy,

and

and their trunks towards the work. When the branches of the trees are well intermingled, and their trunks either buried obliquely in the earth (Pl. 2, fig. 5, a), or fastened to the ground by means of strong pickets driven across them, they cannot be removed so as to effect a passage through them, without great difficulty. It must however be understood that the abattis should lie under the musketry fire of the breastwork, and ought therefore not to be more distant from it than 200, or 250 yards, otherwise the enemy would have no trouble in making an opening through it.

In case there is not a forest in the neighbourhood of the post, the trees must be dragged to the work from a considerable distance: it is therefore evident that the formation of an abattis is connected with other circumstances; and that it cannot easily be completely executed unless there are trees upon the spot, so that nothing is requisite but to fell them.

§ 54.

A FIFTH OBSTACLE.—TROUS-DE-LOUP.

TROUS-DE-LOUP are holes six or eight feet wide, and from four to six feet deep; which are placed about five or six feet asunder, in a straight line, in front of the breastwork, and about 16 or 20 feet from the counterscarp. They may be either round

or

or square*; and three or more rows should be disposed before one another, in such a manner that the holes of one row may occupy the spaces between those of another. In the middle of each hole, a stake about three or four feet long, and four inches thick, may be driven and pointed at top (Pl. 2. fig. 5. b).

Three rows of trous-de-loup as represented in fig. 6, present at all times a formidable obstacle to an enemy; as they cause him to remain a long time exposed to the fire from the breastwork; and they cannot be passed, except by each man singly: so that he will afterwards have to form close under the fire of our grape shot and musketry. They may therefore be made use of with great advantage in any situation where a good defence is required.

§ 55.

A SIXTH OBSTACLE.—CROWS-FEET.

CROWS-FEET, or CHAUSSE-TRAPPES, are pieces of iron having four points, each a few inches in length; and are so formed that in whatsoever manner they are thrown into the ground, one point always remains upwards. When they are planted in the bottom of the ditch, or in the

* The Author alludes to the figure of the trous-de-loup at the surface of the ground, or their shape at top: but they are usually pointed at bottom; so that the form will be an inverted cone, or an inverted pyramid, respectively as the top is a circle or a square. TRANSLATOR.

ground in front of the breastwork, they are of great effect in keeping off an enemy: however as it is difficult to carry such a number of them as would be required for a large intrenchment, they are scarcely ever made use of, except to facilitate the defence of certain spots particularly exposed to danger.

Instead of crows-feet, a great number of stakes, each about a foot long, pointed and capped with iron, may be driven into the ground. But this likewise requires much time, and is attended with many difficulties; therefore this means like the former, ought only to be applied to increase the defence of any particular part of the work.

§ 56.

A SEVENTH OBSTACLE.—AN ADVANCED DITCH.

Several engineers in addition to the usual ditch before a breastwork, form a second ditch in front of the former, and distant from it about 30 yards. This they call AN ADVANCED DITCH; and assert that the same advantage is derived from it, as from trous-de-loup. When such a ditch can be filled with water, or enfiladed from the breastwork, it undoubtedly presents a very considerable obstacle to the enemy in his attack: but on the contrary, when neither of these can be accomplished, it only affords him a place of shelter, where he may rest for some time in security; and having recruited his strength, may make good the

remainder of the distance to the work, in the greatest haste: so that it becomes a detriment instead of an advantage to a garrison.

We shall hereafter see how the enfilade of the advanced ditch may be effected.

§. 57.

AN EIGHTH OBSTACLE.—AN ARTIFICIAL INUNDATION.

Since a breastwork derives great security from a river in its front, or any piece of water sufficiently deep to prevent an enemy's wading through it; it follows that AN ARTIFICIAL INUNDATION OF THE COUNTRY IN FRONT OF THE WORK, must likewise be an excellent means of keeping off an enemy. However it requires such a combination of circumstances to effect this properly, that it can rarely be executed in the field; even though a brook suitable for the purpose, runs immediately in front of the work. Nevertheless a field-engineer ought to have some knowledge of the method of preparing an inundation, as situations may at times occur, where the greatest advantage would be gained from it; and he might thereby be enabled in certain important posts, to add such a degree of strength, as could not possibly be obtained by any other means whatever. For this reason, although it is not here necessary to discuss the subject very fully, I shall treat of such points as particularly relate to an inundation in the field.

the remainder of the distance to the work, in the greatest haste: so that it becomes a detriment.

§ 58.

METHOD OF PREPARING AN INUNDATION.

A rivulet or brook, however small, running by a work, provided its distance from it is not too great, frequently affords an opportunity of forming an inundation: for if a dam be thrown across the brook, and prolonged on both sides of it, the water being thereby unable to continue its course, must swell; by which means the country above the dam will be laid under water. For example; if *ab* (Pl. 3. fig. 1.) be a breastwork, and *dc* a small brook running in front of it, at a convenient distance: by making a dam *ef* across it, the water which runs from *d* is obstructed, and can no longer proceed towards *c*; but as the quantity of water flowing from *d* is continually increased, the river must rise above its banks, and overflow the neighbouring country; until at last it creates for itself new channels, and runs off at *g* and *h*.

§ 59.

It is evident that an inundation is no obstacle to an enemy, unless it is at least five feet deep; as otherwise he might wade through it: and should he adopt that resolution, it is very probable that the garrison thinking such an attack scarcely possible, would be disconcerted, and thereby make a bad defence.

Suppose the banks of the brook to be of such a nature that the points *e* and *f* are only two or three feet higher than the bottom of the stream at *i* and *k*; the depth of the inundation here cannot exceed three feet. Or if the points *e* and *f* are even six feet higher than the bottom of the brook at *i* and *k*, but only three feet higher than its bottom at *d*; in this case also it is impossible to obtain a sufficient depth of water along the whole front of the breastwork. Therefore in such situations, either the idea of an inundation must be entirely abandoned, or recourse must be had to the following means. In the ground proposed to be overflowed, a number of pits are dug about four or five feet deep, as represented by *l*: the earth excavated from these holes may either be spread out in the adjacent country, or employed in the formation of the dam. The dam is next constructed, which causes the inundation; by which all these pits are filled with water, the depth above them being thereby increased to six or seven feet.

As these pits are concealed from the enemy's sight, he must fall into them in his attempts to pass the water; which would throw him into great disorder; and probably oblige him to abandon his intention of wading through the inundation; which without this device would be but very shallow.

Suppose the bank of the brook to be of such a nature that the points $\$0.60$ are only two or three

EXAMINATIONS WHICH MUST TAKE PLACE BEFORE AN INUNDATION CAN BE FORMED.

Previous to the actual formation of an inundation, the following circumstances should be accurately ascertained.

Ques. 1. How much the height of the surface of the water at d (fig. 1); exceeds the height of the surface at k ; or which is the same thing, how much fall the water has from d towards k .

9. How much higher the banks of the brook are at *e* and *f* than at *i* and *k*? Lastly, why is

8. Whether there is any place immediately in front of the breastwork, and higher up the stream, where the banks are lower than at *e* and *f*; should that be the case the water would there run out, and might overflow our intrenchment, before it attained the height of *e* and *f* at the dam.

A perfect knowledge of the respective heights of different parts of the ground, may be acquired by the operation of levelling.

METHOD OF LEVELLING IN THE FIELD.

It is not necessary here to explain the method of levelling in the most accurate manner. Indeed an engineer has seldom opportunities of performing it

it with great exactness in the field ; and it is generally sufficient for purposes of this kind, to ascertain the nature of the ground nearly correct. When there are water-mills in the neighbourhood, the fall of the water may be usually known from the millers.

Captain Tielke, in his Instructions to Field-Engineers *, proposes a method of levelling in the field, which though neither expeditious, nor very accurate in practice, especially for great distances, merits nevertheless to be noticed ; as it may be executed without the use of mathematical instruments.

1. According to the length and nature of the ground to be levelled, a dozen or more wooden pickets must be prepared of different lengths, from half a foot to six feet; and for greater convenience they ought to be marked at every inch from the top downwards.
2. There is also required a mason's level, about 10 or 12 feet long, with a line and plummet, as commonly used (Pl. 3. fig. 2. *g f*).
3. In order to discover the fall of the ground *a b*, a small picket is driven at *a*, until its top is within about two inches of the ground: another is driven at *c*, about 10 or 12 feet from *a*. The level is then laid upon these pickets, and the latter at *c* must be driven

* See § 427—429 of Colonel Hewgill's English translation of the above-mentioned work; in which the various duties of a field-engineer are discussed in a most ample and skilful manner.

TRANSLATOR.

down,

down,

bring down, until the plumb-line exactly coincides with the perpendicular line marked upon the level; and consequently the tops of the pickets will be in a horizontal line. The height of the picket *c* above the ground, must next be measured; from which the height of that at *a* must be subtracted; and the difference will be the fall of the ground from *a* to *c*.

In like manner may be found the fall from *c* to *d*, from *d* to *e*, and from *e* to *b*; and if the height of the picket at *a* be subtracted from the height of that at *b*, the whole fall from *a* to *b* will be known*.

§ 62.

NATURE OF THE DAM.

Having obtained a sufficient knowledge of the ground; when we proceed to the actual construction of the dam, the following remarks must be attended to.

* There is no necessity to drive so many intermediate pickets; for if the first level from *a* to *c* be carefully performed, the entire fall from *a* to *b* may be easily found in the following manner: Three rods must be prepared of equal lengths, each about three or four feet, with a slip of wood fixed perpendicularly across one end. A long picket is then placed at the extremity *b* of the line to be levelled; and the three rods being held with the cross-slips upwards, upon the pickets *a*, *c*, and *b*, a person looking over those at *a* and *c*, must direct the picket *b* to be driven down until the tops of the three rods are exactly of the same height; and of course the tops of the pickets are then on the same level. This operation is called *boning*. TRANSLATOR.

1. The dam must every where be at least a foot higher than the water will rise, except at one or both ends, which should be left so low that as soon as the water has attained its proper height, the rest may run off: but as the dam will there have to sustain a great pressure of water, it should be rounded at the ends, and have a very great slope; and in order to resist the force of the water, and prevent the dam being carried away, the slope should be retained by means of fascines, or hurdles, or even by an entire revêtement of boards.

§ 63.

2. The length of the dam is regulated by the nature of the banks of the stream, and the neighbouring country; and varies according as the ground is flat, or considerably elevated.

The flatter the country on both sides, the longer the dam must be; and, on the contrary, the more rapidly the ground rises, the shorter the dam. For example, if the section of the stream and adjacent ground is similar to that represented in (Pl. 3. fig. 3.), the dam must extend from *a* to *b* in order to obtain a sufficient depth of water in the middle; but if the profile is like fig. 4, it need not be longer than *ab* to procure the same depth.

The proper length of the dam may in every case be easily found, by erecting a perpendicular *ef* (fig. 3. and 4.), in the middle, or deepest part of the brook, of the same height as it is intended

the water of the inundation shall rise: then a horizontal line drawn through the point f , determines the points a and b on the adjacent ground; and consequently ab is the required length of the dam.

It is evident that if our breastwork is situated at x (fig. 3.), the dam cannot be carried from a to b ; and therefore we must in this case be contented with a shallow inundation, and follow the rules prescribed in § 59.

Lastly, if the ground on both sides of the brook is perfectly level, all idea of overflowing the country must be abandoned: but if the banks are very high, by throwing a dam across it, a sufficient depth of water may be obtained within the brook, to render the wading it impossible. For example, if aeb (fig. 5.) is the section of a canal, its greatest depth fe being about eight feet: now even though the usual depth of water in the stream does not exceed two feet, nevertheless by means of a dam, a depth of seven feet may easily be procured. However the water must not be suffered to rise above the dam, and for this purpose proper wooden channels should be laid at both ends, through which the water may run off as soon as it has attained the required height. In permanent fortresses a sluice is generally constructed in the middle of the dam.

§ 64.

3. A dam ought in all situations to be so strong that it cannot be destroyed either by the continued pressure of the standing water, or by the impulse of the running water: and where there is reason to expect an attack with artillery, it must be sufficiently substantial to resist cannon shot. The breadth at top should never be less than four feet.

4. The greater the slope of the dam on the side opposed to the stream, the more effectually it resists its power; and therefore it is usual to make the base of this slope at least equal to twice the height. The other side of the dam may be constructed according to the general rules for the bases of slopes. Both slopes, but especially that towards the stream, ought to have a revetement of sods, fascines, or hurdles, to render it more solid; and the earth may even be secured by strong stakes or piles.

5. It must be observed that the dam should always make an oblique angle with the stream; by which means the water is diverted sideways, and has not so much effect upon the dam, as if it was perpendicular to it.

§ 65.

6. The whole length of the dam ought to be laid under the fire of the work; for if the point *f* (fig. 1.) is situated further from the breast-

work ab than a musket can carry, an enemy may approach, and break through it without obstruction; by which the whole dam must give way. Therefore if it is requisite that the dam should extend to f , a new breastwork must be thrown up, about the middle of the dam, in order to protect it. For example, ab (fig. 6.) represents such a long dam, and cd a breastwork erected for the defence of the part ad . In this case the communication between the new work cd , and the intrenchment fg , must be covered in such a manner that the soldiers may pass and repass unmolested, and even unseen by the enemy. The most simple method of effecting this is by two rows of palisades.

§ 66.

7. If there should still be reason to imagine the dam may either be carried away by the force of the water, or ruined by the effect of the enemy's artillery; it is adviseable to construct several dams at certain distances from one another. Three dams are represented in fig. 7.

It is also necessary here to remark, that those dams which lay furthest down the stream, ought always to be as much higher than those above, as the fall is greater in the former situation, than in the latter: and in many cases their length must likewise be greater.

A NINTH OBSTACLE.—FOUGASSES.

A **MINE** is a general term for a cellar or pit made in the ground, and filled with gunpowder; which being fired, the earth together with every thing else above it, is sprung into the air.

A mine may be formed by two different methods.

1. If a hole or well, not exceeding 10 or 12 feet in depth, is dug on the spot where it is intended to place the mine; and the necessary quantity of powder being lodged, the hole is again filled up, it is called a **FOUGASSE**.

2. A passage or gallery may be carried under ground, for a considerable distance to the spot where the mine is to be laid. A mine of this nature may therefore be called a **PERMANENT MINE**.

In the field, fougasses are commonly made use of, as being most easily and speedily formed; and when well executed, may be regarded as an excellent means of obstructing an enemy's access to a work.

I shall hereafter fully explain the several circumstances necessary to be attended to in the construction of fougasses; and shall here only give some account of the terms made use of respecting them.

The

The pit in which the powder is lodged, is called the CHAMBER OF THE MINE (Pl. 3. fig. 8. *a*).

The fire is conveyed to the powder by means of a tube, *a c e d*, laid under the earth, and extending from the chamber to the place *d*, where it is to be lighted *.

This tube is made of linen or fustian; and when filled with powder, and buried in the ground, is named A SAUCISSON.

The perpendicular line *a b*, drawn from the chamber to the nearest point on the surface of the ground, is termed THE LINE OF LEAST RESISTANCE; and the cavity formed by the springing of the mine, THE FUNNEL, a section of which is represented by *f g h*.

§ 68.

Fougasses are placed about eight or twelve yards from the ditch, in front of the breastwork; and the spot where the fire is applied, is about 18 or 20 feet within the work.

The mine should be sprung when the enemy is on his march towards the breastwork, and at the moment that he is directly over it; by which part of his troops would be blown up into the air, and the rest thrown into great confusion.

The actual injury or loss of men which an enemy sustains by the effect of a fougass, is indeed

* This place is called in German *Minenbeerd*, and sometimes in French *foyer*. Both these signify *the hearth*, but I do not believe it is a usual English expression. TRANSLATOR.

never very considerable: nevertheless it occasions disorder; and soldiers have usually a great dread of mines, and anxiously endeavour to avoid an attack upon any spot which they conceive to be undermined: they therefore become an excellent means of securing a breastwork against the attack of an enemy.

CHAPTER III.

OF THE CONSTRUCTION OF THE BREASTWORK.

§ 69.

WHEN a breastwork is to be constructed and put into a proper state of defence, it must first be traced; that is, not only its situation and length, but the entire plan of it must be marked out upon the ground, in such a manner that the workmen may afterwards be enabled to see the thickness of the work, and breadth of the ditch.

§ 70.

LENGTH OF THE BREASTWORK.

The length of the breastwork must be determined before it can be traced; and is regulated either by the extent of ground to be occupied, or by the number of men and guns destined for its defence. In the former case it is evident that the greater the extent of ground to be covered, the longer the breastwork must be. In the latter, two feet are allowed for each file of men, therefore twice the number of files will be the length of the work in feet: and as troops are usually formed two deep for the defence of a work, the length will be equal to the number of men. Ten feet are allowed for a small gun, and 14 or 16 for a larger; hence
having

having the number of guns, the length to be added to the work on that account is easily found.

§ 71.

CALCULATION OF THE LENGTH OF THE BREAST-
WORK*.

To find the length of a breastwork when the number of men and guns for its defence is given :

If the troops are to be formed two deep, and the guns are light field-pieces,

Multiply the number of guns by 10, and add the product to the given number of men.

For example, to find the length of a breastwork for 250 men, and four field-pieces :

To the number of men = 250

Add $4 \times 10 = 40$

The sum = 290 is the required length of the work in feet.

§ 72.

CALCULATION OF THE GARRISON.

From the given length of a breastwork, to de-

* In the original work the following calculations are given in paces of two feet each; but as the length of a pace is variable at the option of every person, I conceive it much better, and equally easy, to adhere to some established measure in all computations. When the length of a work is ascertained in feet, or any other measure, it may undoubtedly be convenient, and sufficiently accurate in the field, to lay it out by means of paces; which any person may easily do, who is accustomed to take equal steps, and knows how much a certain number of them actually measure. TRANSLATOR.

termine the number of men, which with a certain number of guns, is requisite for its defence :

Multiply the number of guns by 10, and subtract the product from the given length of the work.

For example, if the length of the breastwork is 400 feet, and there are four guns,

From the length of the work = 400 feet

Subtract $4 \times 10 = 40$

The difference = 360 is the number of men required.

§ 73.

METHOD OF TRACING THE BREASTWORK UPON THE GROUND.

When the length of a breastwork is determined, there is no great difficulty in tracing it upon the ground.

For this purpose, a cord of the proper length is stretched out in the intended direction *ab*, (Pl. 4, fig. 1.), of the work: the ground is then notched with a spade, along both sides of the cord, and the earth thus cut is removed; thereby leaving the direction and length of the work clearly marked upon the ground. This is called **LOCKSPITTING***.

* The German word here is *Kieblspitzen*. I have made use of the term by which the operation above described is generally expressed in English; and which is evidently derived from German words having nearly the same signification with that in the Original.

TRANSLATOR.

§ 74. Having

§ 74.

Having determined the principal line of the breastwork, its thickness, and the breadth of the berme and ditch, must be marked out in a similar manner. For which purpose,

1. At the points *a* and *b* (Pl. 4, fig. 1.) two perpendiculars are drawn.—It is useful to practise raising perpendiculars by the eye, as the necessary instruments cannot always be procured.
2. The thickness of the breastwork is next set off from *a* to *g*, and from *b* to *h*, which must include not only the upper thickness of the work, but likewise the bases of both slopes: the slopes are afterwards regulated when the actual construction of the work takes place.
3. The lines *gh*, *ag*, *bh*, are then traced in the same manner as the line *ab*; and the rectangular figure, *aghb*, will represent the space intended to be afterwards covered by the breastwork.
4. If there is to be a berme in front of the work, its breadth is set off upon the above mentioned perpendiculars, from *g* to *l*, and from *h* to *m*; and the line *lm* is marked out.
5. Lastly, the upper width of the ditch is set off from *l* to *p*, and from *m* to *q*; and the

lines lp , pq , qm are traced: so will $lpqm$, be the horizontal surface of the ditch.

§ 75.

The breastwork and ditch being marked out upon the ground, the earth must be excavated from the ditch, and the breastwork erected. It has already been shewn (§ 29.) that at the time of determining the profile of the work, the nature of the soil must be well considered; so that it remains here only to speak of the various materials which may be employed for the revetement of the slopes.

§ 76.

OF SODS.

First of all, sods may be used for a revetement; and the following remarks respecting them should be attended to.

1. The best sods are cut in moist but good meadow land; where the grass grows thick, and the ground is overgrown with roots. Each sod should be about a foot in length and breadth, and five or six inches thick; which thickness when they are rammed together in the work, will be reduced to about four inches.
2. The necessary number of sods is easily computed. As each sod is a foot in length, the revetement of a side of the breastwork requires

requires as many sods placed close to one another, as there are feet in the length of the work; and as each sod is four inches thick, three sods must be reckoned for every foot of height: so that when the interior slope of a breastwork is to be formed of sods, the number of feet in the length and breadth of the work must be multiplied together, and three times this product will be the required number of sods for the slope. But as some sods must frequently be spoiled, an allowance of one-tenth of the number thus found, should be added to supply the deficiency.

For example; if the length of the interior slope of a breastwork is 324 feet, and its height six feet,

$$\begin{array}{r}
 324 \\
 \text{multiplied by } 6 \\
 \hline
 1944 \\
 \text{This product multiplied by } 3 \\
 \hline
 5832
 \end{array}$$

Add one-tenth of the above 583

Their sum 6415 is the whole number of sods.

3. A soldier can conveniently cut 1000 sods in a day, consequently seven men may easily cut the above number 6415 in one day.

As soon as they are cut, other people are appointed to remove them to the spot where

they are to be used: and according to the distance from the work, it must here be considered, what number of men will be sufficient for that purpose; and whether it may not be better to transport them in wheelbarrows.

§ 77.

OF FASCINES.

A revetement for the slope of a breastwork may likewise be formed of fascines; which are bundles of brushwood bound together, at intervals of a foot, by twigs of willow or of birch. They are usually from six inches to a foot in diameter, and six feet or more in length. The larger kind are called SAUCISSONS.

The best wood for fascines is birch, and they are prepared in the following manner:

1. Stakes six feet long are driven by pairs cross-wise into the earth, in such a manner that they may cross one another about three feet above the ground. The distance from one cross to another is two feet; therefore there will be half as many of them as there are feet in the length of the fascine: so that three crosses are requisite for one of six feet; and in making the fascine, four feet of it will rest upon the crosses, and one foot will project at each end. (Pl. 4, fig. 2.) All the crosses together are termed a

FASCINE

FASCINE BENCH*. At each end of the bench, at a foot from the extreme crosses, pickets, *d* and *e*, are driven into the ground, and serve to regulate the length of the fascine.

2. Upon these benches the brushwood is laid, in such quantity as to be about two inches thicker than it is intended the fascine shall be; by which means it will become of the proper size, when bound together. In order that the fascines may all have an equal thickness, a wooden gauge of the proper diameter should be prepared.

3. The brushwood is then drawn together by means of a **CHOKE** (*g*), which consists of a couple of round sticks, about two feet long and an inch thick, fastened to the ends of a cord, which is barely so long as the circumference of the fascine. By applying the choke round the fascine, two men with the help of the sticks, can draw the brushwood together very tight.

4. The fascine is then firmly bound together. The twigs of willow or birch made use of for this purpose should be very tough and pliable; and all the knots which fasten the bands ought to be tied on the same side of the fascine.

* These crosses are also called *a borse*. TRANSLATOR.

5. Lastly,

5. Lastly, to every fascine, several pickets should be prepared from three to four feet long, and one inch and an half thick, which serve afterwards to fasten the fascines to the ground, and to one another.

§ 78.

Six workmen are allowed to every fascine bench; two to cut the brushwood, two to place it upon the bench, and two to bind the fascines. But it is not easy to ascertain the number of fascines which can be made in a certain time at one bench. Tielke says that in a day, we may reckon from 30 to 40 fascines of six feet long; from 16 to 20, of 12 feet; and from 10 to 12, of 14 feet. Gaudi and Marquard maintain that in every hour 10 or 12 fascines may be finished, each of them from 10 to 12 feet long, and bound together at distances of a foot and an half. Here indeed is a very great difference; but perhaps Tielke speaks of fascines made in a careful manner, and the others of such as are slightly formed.—As field-works must generally be executed with haste, I will assume that at each bench six or eight fascines may be completed in an hour.

§ 79.

The fascines employed for the revetement of the slope of a breastwork are usually 12 feet long; therefore

therefore the number of fascines in each row will be equal to one-twelfth of the length of the work in feet: and as the diameter of such a fascine is about a foot, there need properly be only as many rows of fascines above one another, as there are feet in the height of the work; however as at least one half of every fascine in the lowest row should be buried in the ground, and as the height of every slope is greater than the perpendicular height, an additional row ought to be allowed on this account.

Agreeable to this rule the necessary number of fascines for the revetement of every work may be easily found. Thus for the interior slope of a breastwork; divide the length of the work in feet by 12, and multiply the quotient by one more than its height in feet: the product will be the required number of fascines.

For example, if the length of a breastwork is 336 feet, and its height six feet: then the number of fascines necessary for the revetement of this slope will be $\frac{336}{12} \times 7 = 196$.

In like manner may be computed the number of fascines for the exterior slope, the cheeks of the embrasures, or any such purpose; and consequently the number requisite for the entire construction of the breastwork is easily found.

The exterior slope however is seldom revetted with fascines; at all events not above two or three feet in height: and it is likewise better to retain the

the cheeks of the embrasures with sods, as fascines are only proper in cases of necessity.

An addition of five fascines to every hundred should also be allowed to supply deficiencies.

§ 80.

Having computed as above (§ 78.) the number of fascines which may be made in an hour at each bench, it is easy to determine how many benches must be employed, to complete a certain number of fascines in a given time.

When the fascines are finished they should be laid upon one another in several heaps, on the spot where they are to be used; in such a manner as to be perfectly convenient to the workmen. Lastly, in carrying up the work, they should be placed, not with the ends of the fascines in one row exactly over those in another, but in the manner of the stones of a wall, by which means they will be much firmer; and they must always be well fastened together by small pickets, as was already mentioned (§ 77).

§ 81.

OF HURDLES.

The revetement of a slope is sometimes composed of hurdles; and the only materials requisite for this work are stakes of a suitable length, and two

or

or three inches thick, with a proper quantity of willow twigs.

The hurdles are prepared in the following manner :

For example, to make a hurdle six feet long and four feet broad. (Pl. 4, fig. 3.)

1. At distances of 10 inches or a foot, in a straight line, stakes four feet and an half or five feet long are driven a few inches into the ground. Their number depends upon the length of the hurdle.

2. The willow twigs are next wattled about the stakes, in the same manner as basket work is performed, or a hedge made. The chief object of attention is, that the weakest ends of the willow branches should always be twisted round the outermost stakes, by which means the hurdles become firm and equal at both ends : and in order that the twigs may not afterwards start from the stakes,

3. The last twigs must be firmly fastened to the stakes, and secured by cross bands.

4. Lastly, the hurdle is taken out of the ground ; and the points at both ends of the stakes being sawed off, it is ready for use.

§ 82.

OF GABIONS.

Having shewn the manner in which hurdles are formed, I will now explain the method of making gabions. They are usually two feet and an half or three feet wide, and from three to six feet high; and are prepared in the following manner.

To make a gabion three feet wide and four feet high. (Pl. 4, fig. 4.)

1. Seven, nine, or eleven stakes of four feet and an half in length, are driven three or four inches into the ground, so as to represent a circle of three feet diameter. For this purpose the circumference of the circle should be traced upon the ground beforehand, by means of a cord a foot and an half in length, to which a picket is fastened: or a board (fig. 5.) may be prepared, suitable to the plan of the gabion, having notches cut in its circumference, in which the stakes are fixed.

2. The stakes being inserted in the due direction, a strong wreath of willow twigs is wattled round them quite at top, and another at bottom; after which the work is continued in like manner from the bottom upwards, until the whole gabion is formed. However, when about half this work is finished, the upper wreath would become incom-

incommodious, it is therefore either entirely removed, or driven down to the rest of the twigs; and the gabion then completed. To render it more firm, another strong wreath is afterwards made at the top; and for the same reason, during the process of the work, the wattled twigs should from time to time be driven together by blows. Lastly, whenever it is necessary to make knots in order to tie the thin twigs together, they ought always to be turned towards the inside of the gabion.

Four men are appointed to prepare a gabion, two of whom cut the materials and transport them, and the other two execute the work.

The sixth figure represents a complete gabion.

§ 83.

OF PALISADES, FRAISES, AND CHEVAUX-DE-FRISE.

I need not explain the manner of preparing palisades, fraises, and chevaux-de-frise, as this work is easily performed by carpenters accustomed to it; but shall here only consider the method of determining the necessary number of these materials, and the time and number of workmen requisite to execute them.

Three palisades, or three fraises are allowed to every two feet: therefore when either of these are to be fixed in any line, their number will be found

- by

by multiplying the length of that line by three, and dividing the product by two.

For example, if the length of a ditch, or of a breastwork is 270 feet; the number of palisades requisite for the former, or of fraises for the latter,

$$\text{is } \frac{270 \times 3}{2} = 405.$$

Some laths will also be necessary for the palisades, (§ 47.) and consequently a sufficient supply of nails.—The fraises rest upon a beam, and are covered by another behind. (§ 51.) Very strong fraises may serve for this purpose, and therefore to every hundred, twenty such should be prepared, without being pointed.

Two carpenters can make about 10 palisades or fraises in an hour; and hence it is in every case easy to determine the number of carpenters requisite to prepare a certain number in a given time.

The formation of chevaux-de-frise requires much time, and dexterous workmen: therefore unless there are some ready made with the army, they can rarely be made use of in the field. When that is the case, it is very easy to ascertain how many are wanted, according to the length of a cheval-de-frise, and that of the line where they are to be placed.

§ 84.

OF THE WORKMEN FOR THE CONSTRUCTION OF
A BREASTWORK.

I shall take notice of the necessary materials for fougasses and dams hereafter, when I treat of their construction; and shall now mention the workmen who are employed in the formation of a breastwork.

All field-work must be executed either by soldiers or peasants. When there is nothing to apprehend from the enemy, the country people may be employed; which is a great relief to the troops. But if the enemy is near, these people will run away at every opportunity; and even when they are attentively watched, the work proceeds very badly; consequently in this case it should be performed by soldiers.

Soldiers ought likewise to be employed wherever it is requisite for the work to be carefully and well executed, as that done by peasants in general is not sufficiently good. Thus for example, the breastwork, and every thing immediately belonging to it, should always be erected entirely by the troops.

§ 85.

When country people are to be employed, and the necessary number is determined, they are demanded of the magistrates; who are expressly enjoined

enjoined to take care that the complete number is furnished at the proper time: and as the most useless workmen are generally sent upon these occasions, there ought always to be more demanded than are actually wanted; and the tools they are to bring with them should likewise be specified.

The magistrates must also give a written account of the number of workmen each village or territory is to furnish; that it may be known upon their arrival whether any of them have failed to comply with the requisition. When they are assembled, they are distributed to the several parts of the work, and placed under the inspection of non-commissioned officers.

If they cannot be relieved, they must be detained at the post all night; in which case care must be taken to provide for their subsistence, and to keep a good watch that they do not run off.

§ 86.

NUMBER OF WORKMEN.

When a work is to be executed with all possible dispatch, as many labourers should be employed as can work without incommoding one another: it is therefore proper here to consider what number may be thus disposed.

First, with respect to the excavation of the ditch. If it is tolerably broad, workmen may be placed along the scarp *lm*, (Pl. 4, fig. 1.) and likewise along the counterscarp *pq*; but if it is very narrow,

narrow, only one row can be employed. Each workman who is to dig the earth, and throw it forwards, requires a length of four feet; so that the number of men on the scarp lm , will be equal to a fourth part of the number of feet in its length. As many men might also be placed along the counterscarp pq ; but they could only throw the earth to those at lm , who would therefore be entirely occupied in throwing this earth on the breastwork. For this reason, only half that number are placed along the counterscarp, by which means only every second man on the scarp is employed to forward the earth thrown to him from the counterscarp. Three workmen are therefore allowed to every eight feet in length, and consequently having the length of the ditch, it is easy to calculate the necessary number of workmen.

For example, if the length of the ditch is 324 feet.

$$8 : 3 :: 324 : \frac{324 \times 3}{8} = 121.$$

Therefore, in this case, 121 workmen are required, who must be provided with spades and shovels.

When it is a clayey or gravelly soil, to every three men with shovels, one with a pick axe should be reckoned, to loosen the ground, and thereby render it more easy for those with shovels. Therefore in the example given above, 40 men with pickaxes are likewise necessary.

§ 87.

At the same time that the workmen are throwing the earth from the ditch to the breastwork, others are employed to carry up the interior slope, to spread the earth upon the work, to ram it together as much as possible, and thereby complete the breastwork. When all the materials necessary for this purpose are prepared, and at hand, the number of men for this work may be taken at about one-fourth the number of feet in the length of the breastwork : so that 81 men are requisite in the foregoing example.

§ 88.

From the above computation (§§ 86, 87.) is found the number of workmen that can be employed at the same time : but the work will be more speedily accomplished if they can be relieved every six hours ; as it may thereby be continued throughout the whole day. For this purpose there should be twice as many men as can work at the same time.

When the work is to be carried on entirely by those men who are afterwards to compose its garrison, either this relief cannot take place, or all parts of the work cannot be begun at the same time. The manner of carrying on the work with most advantage, becomes in such cases a circumstance of consideration.

§ 89. INTRENCH-

§ 89.

INTRENCHING TOOLS.

The tools which these workmen are to use are either furnished from the park of artillery, or in cases of necessity procured from the neighbouring villages. The particular kind of tools is determined by the nature of the ground to be excavated. In most cases it is proper for each man who is to dig and throw up the earth, to be provided with a spade, and a shovel; and each of those who loosen hard and stony ground should have, a pick-axe, and a broad axe.

§ 90.

CALCULATION OF THE TIME NECESSARY TO
COMPLETE A BREASTWORK.

From the manner in which the workmen are disposed in the ditch (§ 86.), it is evident that for the space of four feet, only one man actually digs up the earth; and consequently the entire quantity of earth within that space must be excavated by a single man. This piece of earth is a prism whose base is the section of the ditch, and altitude four feet; therefore the number of cubic feet of earth to be excavated by a single man, will be found by multiplying the area of the section of the ditch, by four.

For example, if the area of the profile of the ditch is 77 square feet (§ 43.): then the quantity to be excavated by each man is $77 \times 4 = 308$ cubic feet.

Now, if we suppose that a man can dig 144 cubic feet of earth in six hours, he will require nearly 13 hours to excavate the above 308 feet. Therefore if the workmen are relieved every six hours, two reliefs may very easily complete the whole work. However it must here be observed that the nature of the soil, and other circumstances frequently cause a great deviation from this computation.

§ 91.

The breastwork ought properly to be finished in the same time that the ditch is formed. For this purpose it is necessary that all the materials should be at hand, and they must therefore be prepared before the actual construction takes place.

A breastwork with a revetement of sods may in general be completed in a day, provided there is a sufficient number of workmen. But if it is to be formed with fascines, or to have a row of palisades, it will require at least two days. And if there are likewise to be fraises, trous-de-loup, fougasses, &c. three days may not be sufficient.

§ 92. ACTUAL

§ 92.

ACTUAL CONSTRUCTION OF THE BREASTWORK.

After all these preliminary discussions, I will now proceed to explain the actual construction of the breastwork, and various other particulars for its security.

In the first place, the workmen in the ditch should be cautioned not to make the slopes too steep, especially the scarp. If necessary, they may afterwards be rendered steeper, by cutting more of them away.

§ 93.

MANNER OF FORMING THE REVETEMENT OF THE INTERIOR SIDE OF A BREASTWORK, WITH SODS.

When the interior slope of the breastwork is to be carried up by means of sods,

1. A row of sods is laid along the line *ab* (Pl. 4, fig. 1.), with the grass side downwards; and if the sod is not equally broad throughout, the wide side should be turned outwards, and the narrow side towards the breastwork.
2. Upon the lowest row another is laid; attention being paid that each sod in the upper row rests upon two in the lower row; so that the sods are placed over one another with

with alternate joints, like the bricks of a wall.

3. The work is continued in this manner, placing one row of sods over another, until the proper height is attained.

After each row is laid, the sods ought to be beaten and rammed together, to make them lie closer to one another; by which the work is rendered more compact and firm: and when the last row is placed, the whole must be cut away with the proper slope.

If the breastwork is intended to last long, the roots of the grass may be laid between the sods; which will thereby unite the better together when the roots spring out.

During the time of forming the interior slope in this manner, other workmen are stationed upon the breastwork to spread out the earth uniformly, and ram it well together. Lastly, when all the earth is thrown up, the proper slope is given to the summit and exterior slope of the breastwork, and the whole is dressed off as even and smooth as possible.

§ 94.

WITH FASCINES.

When the interior slope is to be revetted with fascines,

1. A small trench, a few inches deep, is dug along the line *ab* (Pl. 4, fig. 1.), in which a row

a row of fascines is laid close to one another, in as regular a manner as possible. The knots of the bands should always be turned towards the work, that they may afterwards be covered with earth, and not so easily burst open.

2. Every fascine of 12 feet in length should be pinned to the ground by three or four pickets: and to render it still firmer, it may be anchored by means of branches having several twigs. The thick end of such a branch is cut so as to form a hook, which is fastened into the fascine; and the twigs being laid into the breastwork, are covered with earth and secured with small stakes, whereby the fascine becomes so firm that it cannot be removed.

3. A second row of fascines is placed upon the first, and it is necessary here to attend to two circumstances. First, the bands of the upper row should be laid exactly over those of the lower, that the pickets driven through the former may not strike upon the bands of the fascines below them and burst them. Secondly, every fascine in the upper row ought to rest upon two in that beneath it, that their ends may not coincide. These fascines must likewise be picketted and anchored.

4. The work proceeds in this manner until the breastwork is of the proper height. It

must in this case also have a small slope; and as soon as a few rows of fascines are laid, the earth is thrown against them and well rammed; and the whole must be continued in the manner shewn in § 93.

§ 95.

WITH HURDLES.

The method of forming a revetement for the interior side of a breastwork by means of hurdles, is as follows:

1. At distances of about a foot in the line *ab* (Pl. 4, fig. 1.), hedge stakes are driven into the earth. Their length should be such that when fixed in the ground, the part above it may be equal to the height of the breastwork: and in order that the work may have the proper slope, the stakes should be driven in the oblique direction.
2. These stakes are then wattled with brushwood, in the manner formerly shewn (§ 81.) respecting hurdles and gabions.

§ 96.

REVETEMENT OF THE EXTERIOR SLOPE.

The revetement of the exterior side of the breastwork by means of sods, fascines, or hurdles, is executed according to the same rules as that of the interior slope. However it is not customary to

to give any revêtement to this slope, except in situations where the soil is so bad that it will not otherwise hold together.

§ 97.

CONSTRUCTION OF THE BANQUETTE.

The earth for the formation of the banquette is rarely taken from the ditch, as it requires too much time and trouble; but is rather procured from behind the breastwork, and from the embrasures. If there are plenty of fascines, the banquette by means thereof may be very speedily made. Two or three rows of fascines are laid, and the earth is thrown within them, until the banquette is raised to the proper height. (§ 32.) The number of fascines necessary for this purpose is easily computed from their length, and that of the breastwork.

§ 98.

CONSTRUCTION OF A BATTERY EN-BARBETTE.

When cannon are to be placed to fire en-barbette over a breastwork, the earth of which the elevation for this purpose is formed (§ 35.), must be rammed together in as solid a manner as possible, that the guns may stand on firm ground.

This earth is taken from the ditch, and must like that for the breastwork, either be excavated in the beginning, and removed to the spot where it

is

N

is

is to be used, before the breastwork is finished; or it must be transported from the ditch to the proper place behind the work, in hand-baskets or wheelbarrows.

§ 99.

CONSTRUCTION OF AN EMBRASURE.

If, instead of firing en-barbette, embrasures are to be made for the guns, they are constructed as follows:

1. As soon as the breastwork is carried up to the height of two and an half or three feet; the centre line of the embrasure is determined upon it (Pl. 4, fig. 7, *ab*). The direction of this line depends upon the direction in which it is intended the gun shall be fired; and is best when it forms a right angle with the line *xy*.

2. From *a* half the interior width of the embrasure is set off on each side to *e* and *f*; and from *b* half the exterior width in like manner to *c* and *d*. (§ 37.) The lines *ce* and *df* are thereby regulated.

3. The cheeks of the embrasure are erected conformable to the direction of the lines *ce* and *df*, and revetted in the same manner as the interior side of the breastwork.

4. The sole of the embrasure must have the proper inclination; and when every thing is removed and cleared, some fascines are laid

across the top of the embrasure, and picketed on both sides to the work. By this means the artillery-men are rather more covered during the time of loading the gun; and the enemy at a distance cannot so exactly discern the embrasure.

§ 100.

OF PLATFORMS.

In order that a gun may have the due effect, it should stand upon ground which is firm and perfectly horizontal. If the natural ground is sufficiently solid, and the guns are small, it is only necessary to smoothen it, and make it as level as possible. But if the ground is not very firm, and large cannon are to be employed, proper floors of beams and planks must be prepared for them. These are termed **PLATFORMS**.

§ 101.

In cases of necessity, temporary platforms may be made similar to that represented in Pl. 4, fig. 8. This is the most simple but worst kind.

When the earth is smoothened and levelled as much as possible, two strong planks, *ab*, *cd*, are buried in such a manner that the upper sides of them are even with the surface of the ground. Their distance asunder depends upon the width of the track of the gun; and their length should be

such that the wheels may not run off by the recoil. Between these planks and further backwards, two others, *ef*, are laid in the same manner, for the trail of the carriage. All these planks are secured by small pickets driven close to them on every side; and if the ground is so soft that it is apprehended it may sink, strong pickets are first driven into it, and the planks are fastened upon them. Beams six or eight inches thick, may serve instead of planks for these temporary platforms.

§ 102.

A much better kind of platform is shewn in fig. 9. When the ground is made even and horizontal, three or four beams are inserted into it, parallel to one another, and secured by pickets driven close to them into the earth. These beams are called SLEEPERS, and their length is from 12 to 20 feet, according to the nature of the gun. Strong planks exactly of equal thickness are laid across the sleepers, and fastened to them.

The breadth of such a platform is from six to ten feet; but in order that the gun may be traversed so as to command the whole country in front of the breastwork, the breadth behind must be increased sufficiently for that purpose (fig 10).

Lastly, when the gun is to be fired only directly forwards, it is adviseable to give the platform a small inclination towards the breastwork: by this means, not only the recoil is diminished, but the
gun

gun is also more easily run up after loading: and that the breastwork may not be damaged by the wheels in running up, a strong beam, *x*, called a **HURTOR**, is laid at the foot of the interior slope (Pl. 4, fig. 11).

§ 103.

MAGAZINES.

To preserve the ammunition for the guns from dampness, and that it may not be so easily injured by the enemy's shells, small magazines are made at some distance from the breastwork. These are holes dug in the ground behind the merlons. They have a breastwork erected on purpose for their security, and are afterwards covered by boards, fascines, and earth. If the ground is wet, wooden floors must be laid, upon which the powder-barrels stand.

§ 104.

MANNER OF FIXING PALISADES.

I have already treated of the nature and use of palisades, as well as of the method of preparing them, and computing the necessary number; and shall here briefly explain the manner of fixing them in the ground.

A trench is first dug in the direction which the palisades are to have, and of the depth it is intended they shall be sunk in the earth: and if the palisades

sades are to stand obliquely, the ditch must be cut away sufficiently steep to admit of their being placed in that position. Two palisades are then firmly fixed at some distance asunder, with great accuracy, and exactly of equal height. At the points of these palisades nails are driven, and a cord is stretched between them; by which means the situation of all the palisades is determined, and it is easy to fix them sufficiently correct.

§ 105.

MANNER OF FIXING FRAISES.

The following circumstances are to be observed with respect to fraises :

1. They are laid before the breastwork is finished; the earth which is afterwards to cover them being in the mean time thrown back upon the work: but when they are to be applied to a breastwork already completed, the front of the work must be taken down for three or four feet in breadth, and within two feet of the level ground.
2. They are then laid agreeable to the rules given before (§ 51.), and in order that they may all have the same direction, a cord is stretched between two fraises fixed at some distance asunder, as was shewn (§ 104.) with regard to palisades.
3. When all the fraises are fastened to the beam beneath them, and another is laid over

over their hinder extremities and nailed to them, the earth is thrown upon them, and the breastwork carried up in the usual manner.

§ 106.

PREPARATION OF AN ABATTIS.

There is not much to be noticed respecting the preparation of an abattis. In cutting down the trees care should be taken to make them fall into their proper situation. For this purpose each tree is cut to the pith, on the side towards which it is to fall, and is afterwards cut a few inches higher on the contrary side, until it begins to give way. For greater certainty some ropes may be fastened to the upper part of the tree, by which it may be pulled down on the proper side.

§ 107.

FORMATION OF TROUS-DE-LOUP.

When the figure and situation of every trous-de-loup is determined according to the foregoing rules (§ 54.), the earth is excavated and thrown up in heaps between them; or it may be entirely removed, and made use of elsewhere, or spread out upon the ground. In this case the holes may be slightly covered with brushwood, and earth thrown over it, which will prevent their being perceived by the enemy at a distance; and he will therefore
be

be thrown into more confusion, when in his approach he discovers this obstacle.

§ 108.

CONSTRUCTION OF A DAM.

I will here explain as much concerning the construction of a dam, as is generally necessary with respect to inundations in the field.

1. The dam is formed of earth, which is dug from any convenient place: but if various kinds of earth can be procured with equal ease, loam or clay is to be preferred.

2. The slopes of the dam must be executed with the greatest care; and revetted with fascines, hurdles, or good sods. However, if the inundation is not large; if there is not sufficient time; or if the necessary materials are wanting, the revetement of the slopes is rejected. In this case particular care should be taken that the earth is well rammed together, and that the slopes have a very large base.

3. That part of the dam which is in the middle of the stream, and has the greatest force of water to sustain, occasions most difficulty in the construction, and ought to be formed with particular solidity. One or two rows of stakes are driven across the brook, and the dam is erected behind them by means of fascines loaded with stones, earth,

earth, and rubbish: but before this part of the dam is formed, the channels for the water to run off at the ends (§ 62. and 63.) must be established.

§ 109.

CONSTRUCTION OF A FOUGASSE.

I will lastly explain the construction of a fougasse.

1. At a distance of 20 or 30 feet from the edge of the ditch, a shaft, or pit, *A*, (Pl. 4, fig. 12.) is dug, three or four feet square, and 10 or 12 feet deep. If the soil is light, the pit must be lined with boards, which are equal in length to the side of the pit; each board having a notch an inch wide cut half across its breadth, at both ends, (fig. 13.) Four such boards compose a frame, which is fastened in the pit, and prevents the earth falling down. These frames are represented by *a*, *b*, *c*, and *d*, (fig. 12.)

2. At the bottom of this pit, and on the side next the breastwork, a cubical chamber is excavated sufficiently large to contain the box of powder destined for the mine; and if there is any danger of the earth's falling in, this chamber must be lined with boards.

3. A cubical box is next prepared of dimensions exactly sufficient to contain the quantity of powder allotted

allotted for the mine. The size of this box is easily found by geometrical principles*.

The top is left loose that it may be taken off; and in one side of the box a square hole is cut, through which a tube passes to the middle of it; and in which the saucisson is afterwards fixed. If dampness is to be apprehended, both the inside and outside of the box should be pitched over, and it may be wrapped round with straw, or rather with waxed cloth.

4. The box is then filled with powder, and when the top is fastened down, it is placed in the chamber, B.

Should there be an empty space between the box and the sides of the chamber, it should be filled with earth, and wedged up with wood.

§ 110.

5. The saucisson is about an inch in diameter, and as long as necessary. When it is completely filled with powder, one end of it is passed through the tube into the box, and there fastened: the other end is carried under ground in the direction *CDGEH*, to the place *F*, where the mine is fired.

6. In order that the saucisson may not get wet under ground, it is laid in a small square channel

* Dr. Hutton, in his *Course of Mathematics*, Vol. II. p. 262, gives the following easy rule to find the size of a cubical box to contain a given weight of powder:

Multiply the weight in pounds by 30, and the cube root of the product will be the side of the box in inches. TRANSLATOR.

or trough, made of boards, about two inches wide*. A covering is also formed to this trough, which, as soon as the saucisson is laid within it, is placed over it, and nailed down. At the spot where the mine is lighted the trough projects a few inches beyond the saucisson, to preserve it from dampness; and the top at that part ought not to be fastened down, that the saucisson may be conveniently lighted.

7. When there is not much time to spare, the trough is carried across the ditch in the direction *GH*, that part being supported by stakes driven into the ground. If the soil is very dry, and it is known that the mine will soon be sprung, there need not be any trough; but in lieu thereof the saucisson is merely wrapped up in straw for a thickness of four or five inches.

§ 111.

8. When the shaft is to be covered up, three or four pieces of timber are fixed as firmly as possible against the powder box. The pit is then completely filled with earth and sods, well rammed together at every foot.

The small trench made for the saucisson is filled up in like manner.

9. When several mines are to be placed near one another in front of a breastwork, their distance

* This trough is generally called an *Auget*. TRANSLATOR.

asunder ought to be such that when one mine is sprung, those near it may remain unaffected.

The theory of mining teaches us that this properly depends on the quantity of powder with which the mine is loaded. In the field the distance from one fougasse to another should be at least equal to twice the depth: and the charge is regulated afterwards.

It is not necessary in such cases to dig a trench for each saucisson, but several troughs may be laid in the same trench: however they must be of unequal lengths at the part where the fire is applied, that all the saucissons may not catch fire at once, but that each mine may be sprung separately. If several mines are to be sprung at the same time, it is only necessary to have a single saucisson at the place where the fire is put, which afterwards separates into as many branches as there are chambers.

§ 112.

CHARGES OF POWDER.

Every circumstance relating to the construction of fougasses is now determined, except the quantity of powder with which they should be loaded. The principles upon which this is chiefly regulated, do not properly come under the subject of this work; but are discussed and explained in the art of mining*. I shall content myself with laying

* See Professor Geusse's Treatise upon the Art of Mining.

down the following table, given by M. Vauban for the charges of fougasses, when the distance between them, agreeable to § 111, is exactly double the line of least resistance.

Line of least Resistance.	In common Earth.	In deep Sand.	In mixed Soil.	In Clay.	In stony Soil.
Feet.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
2	— 9 $\frac{1}{2}$	— 11 $\frac{1}{2}$	— 12	— 12 $\frac{1}{2}$	— 14
3	1 13 $\frac{1}{2}$	2 3 $\frac{1}{2}$	2 5 $\frac{1}{2}$	2 8	2 12
4	4 6 $\frac{1}{2}$	6 5 $\frac{1}{2}$	5 12 $\frac{1}{2}$	6 —	6 10
5	8 10	10 7 $\frac{1}{2}$	11 1	11 11 $\frac{1}{2}$	12 14 $\frac{1}{2}$
6	14 12 $\frac{1}{2}$	17 14	18 15 $\frac{1}{2}$	20 —	23 2
7	22 2	26 4	26 5 $\frac{1}{2}$	27 7	31 10
8	34 6 $\frac{1}{2}$	42 3	44 5	46 6 $\frac{1}{2}$	52 9
9	55 9	67 8	71 10	75 13	88 —
10	78 9	96 2	100 10	106 4	121 14

CHAPTER IV.

OF SMALL FORTS.

§ 113.

A BREASTWORK may be defended in a three-fold manner, by means of fire-arms.

1. **IN FRONT**, by soldiers and cannon placed behind it, so as to fire directly forwards upon an approaching enemy. For example, *ab* (Pl. 5, fig. 1.) is simply defended in front.
2. **IN FLANK**, from behind another breastwork thrown up so as to make a re-entering angle with that to be defended. Thus the breastwork *ab* (fig. 2.) is defended in flank by the garrison placed behind *bc*. Any line which defends another in this manner is termed its flank: therefore *bc* is the flank to the breastwork *ab*, and reciprocally *ab* is the flank to *bc*.
3. **IN REVERSE**, by means of another breastwork parallel, or nearly so, to that to be defended. For example, an enemy attacking the breastwork *ab*, (fig. 3.) is fired upon in reverse from *dc*.

§ 114. STRENGTH

§ 114. STRENGTH OF DEFENCE.

The strength of defence obtained from any line, depends upon the number of men and guns which can be posted to fire from it: but this is not determined alone by the length of the line, but also by the direction in which the defence is obtained. This direction is called THE LINE OF DEFENCE.

When the line of defence ac (fig. 1.) is perpendicular to the breastwork ab , we may estimate the defence by the length of the line ab ; for whatever number of men and guns can be stationed behind ab , that number is enabled to fire conveniently in a direction parallel to ac . But when the line of defence ac (fig. 4.) makes an oblique angle with the breastwork ab , it is not possible for so many soldiers and cannon to fire commodiously in the proper direction, as might be placed behind ab . For if from one extremity b of the line ab , be be drawn perpendicular to the line of defence ac , the figure shews that there can be no more lines of fire in the direction of ac from ab , than from be . Suppose a soldier takes up the space ef on the line be ; then on the space ab he will require the space ag , and consequently ab will not contain more men for the purpose of firing than be . Therefore the quantity of defence obtained from the line ab , in the direction ac , is determined by the perpendicular be .

But

But if in the right angled triangle abe , the side ab be considered as the radius of a circle; then is be the sine of the angle a : and therefore universally the strength of defence obtained from a given line is as the sine of the angle which that line makes with the line of defence.

Hence, two lines intended to flank each other have the strongest mutual defence when they form a right angle.

When the line of defence is called the line of defence.

DEFECTS OF THE OBLIQUE DEFENCE.

It has already been shewn that when a line makes an oblique angle with another, it does not give the strongest defence; but this is not the only inconvenience attached to the oblique flank.

The soldier is accustomed to fire only straight before him; in order therefore to fire in an oblique direction, he must first arrange himself so as to take aim at the enemy: but this can scarcely be expected of him, especially should he be disconcerted on mounting the banquette; and consequently very little good can be derived from musketry in this case.

It is rarely possible to make use of cannon in a very oblique flank, as the embrasures must for that purpose be cut in the oblique direction (fig. 5.); by which the merlons become very weak, and are therefore more liable to be destroyed by the enemy's shot.

§ 116.

DIRECTION OF THE BREASTWORK.

A breastwork is the more perfect according to the number of defences it receives, and the strength of those defences: therefore in designing a work, the following maxims should be observed.

1. That it not only has a front fire, but is also defended in flank, and if possible in reverse.
2. That the angle formed by those lines which are intended to flank one another, approaches as near as possible to a right angle.

§ 117.

When the direction of a breastwork is a straight line, ab , (Pl. 5, fig. 6.) or a curve line bending outwards, ab , (fig. 7.) or two right lines making a salient angle, as ab and bc , (fig. 8.) it has only a front defence.

Two right lines which make a re-entering angle, as ab and bc , (fig. 9.) afford a flank defence to each other.

Lastly, a curve line bending inwards has of itself all three kinds of defence, ab , (fig. 10.)

Therefore if we wish to enclose a place by a breastwork, every point of which is to be defended not only in front, but also in flank; we must either introduce re-entering angles in its circumference,

ference, or it must be composed entirely of lines curving inwards.

§ 118.

LENGTH OF THE LINE OF DEFENCE.

In order that the breastwork *ab* (Pl. 5, fig. 1.) may flank the line *ac*, the soldiers stationed behind *ab* must be enabled, by means of their small arms, to reach the point *c*: so that this point must not be further from *ab* than a musket can carry; and consequently the length of the line of defence must always be adapted to the range of musket shot. This cannot be reckoned to have any effect at more than 250 yards; therefore the length of a line of defence ought never to exceed that distance.

If indeed it is intended that the flank defence shall consist entirely of artillery, the line of defence may undoubtedly be much longer; but should the guns in this case be rendered unserviceable by the effects of the enemy's fire, there would no longer remain any flank defence. Moreover two kinds of defence are always preferable to one; and that obtained from cannon is in many instances too slow, and likewise more subject to be destroyed by the enemy, than that from musketry. We must further consider that for the same distance where small arms are made use of, guns can also act, whereas the reverse does not hold good; and lastly, that a fire of grape or case shot would be of essential advantage at this distance. Upon these prin-

ciples we have the most substantial reasons for regulating the line of defence suitable to the use of small arms.

§ 119.

DEFINITION OF A FORT.

A FORT is a general term for every place surrounded by a breastwork, and is distinguished by the names of A ROUND OR CIRCULAR FORT, (Pl. 5, fig. 11.) A TRIANGULAR FORT, (fig. 12.) A SQUARE FORT, (fig. 13.) A PENTAGONAL FORT, &c. according as the figure contained within its circumference is respectively A CIRCLE, A TRIANGLE, A SQUARE, A PENTAGON, &c.

Square forts in particular are likewise called REDOUBTS.

When the circumference is composed of lines forming alternately salient and re-entering angles, it is named a STAR FORT; and likewise receives the appellation of A SQUARE STAR FORT, (fig. 14.) A PENTAGONAL STAR FORT, (fig. 15.) &c. according as it has four or five salient angles.

§ 120.

FURTHER CONSIDERATION OF FORTS.

All circular forts, and others having only salient angles, have no defence but in front: and if this defence is considered more minutely, it will be found that there are parts of the ground about the fort which

remain without any defence. For example, in the square fort (Pl. 6, fig. 1.) the soldiers behind ab defend that part of the ground in front of the fort, bounded by the parallel lines ae and bf , which are 250 yards in length. In like manner the ground between the lines, bg and ch , is defended from behind bc : but the right angle fbg , and the entire space included by the lines, bf , bg , and the curve fg , remain totally undefended. Now as there must be at each of the four angles an undefended space equal to the former, it is evident that if an attack is made on all parts of the redoubt, the garrison cannot possibly fire in every direction, so as to defend the whole country.

It may probably be suggested, that if half the troops behind ad were to fire in the direction al , and the other half in the direction dk , the angles a and d would thereby obtain a defence. This is true, but then the right angle m , in front of the line ad , is deprived of its defence; so that in every square work, there must be four right angles undefended.

§ 121.

>

It will be found in like manner, that in a triangular fort, there are three angles without any defence, each of them containing 120° .—In a pentagonal fort there are five angles of 72° each—and in a hexagonal fort there are six angles of 60° each. And in general, in every fort which has merely salient angles, there are as many undefended angles

angles as the fort has sides. All these angles taken together are equal to 360° : therefore each of them is found by dividing 360° by the number of sides. For example a fort which has 10 sides has likewise 10 undefended angles containing 36° each.

§ 122.

The number of undefended angles is greater, the greater the number of sides to the fort; but each of these angles is by the same reason accordingly decreased. Therefore the spaces which have no defence are better divided throughout the circumference of a fort of many sides, than one of few sides: and as the space included within a small angle will not admit so many men in front as that contained by a larger angle; it follows that the enemy cannot derive so much advantage from a number of small undefended angles, as from a few which are large. Consequently the greater the number of sides, the more perfect a fort must be esteemed with regard to its front defence.

§ 123.

ADVANTAGES OF CIRCULAR FORTS.

In the circular fort, the length of breastwork taken up by a single soldier may be considered as a side of the fort; so that in fact it is a fort having as many sides as there are men in one rank behind
the

the breastwork; and therefore it affords a better front defence than any other.

Again, the larger it is, the greater will be the number of ranks in which the troops can be formed, and consequently the more perfect its defence in front.

§ 124.

Notwithstanding these advantages attached to circular forts, it is very seldom that engineers adopt them. Probably this arises from the notion, though without foundation, that works of this kind occasion more trouble in the calculation, tracing, and construction, than those which are rectilinear.

When several works are to be erected with the view that they shall mutually flank one another, circular forts are undoubtedly not eligible; but when a single work is to be thrown up, I esteem one of this figure the best; and the difficulties which occur in the design are of no importance*.

§ 125. CAL-

* Notwithstanding the reasons urged by the author in favour of circular forts, I cannot entirely agree with him.

In the first place there is generally some particular intention in throwing up a work: for example, to command a road, a ravine, or some spot where an enemy's approach is expected. In such cases it is evident that a redoubt which opposes a side, and thereby a line of fire, is to be preferred to a circular work where the fire is so scattered.

But we will even suppose there is no such particular object, and that the ground is equally accessible on all sides. It is clear that

at

CALCULATION OF A CIRCULAR FORT.

To find the dimensions of a circular fort to contain a given number of men and field-pieces.

1. Multiply the number of guns by 10, and add the product to the number of men (§ 74.): their sum will be the length of the circumference of the fort in feet.

at all times the defence of a redoubt is every where stronger than that of a circular work, except at the angles: consequently the whole advantage proposed by the latter, must be to remedy the defects of those angles. Now if the enemy marches by files, he may advance towards the circular work with the same security as towards the angle of a redoubt: but it will even be found that if the circular fort contains 200 men, a column of 10 men in front may approach within 8 or 10 yards of the ditch before it can be hit by five files behind the work; and the whole column may then speedily get into the ditch, and under cover.

The actual defence is therefore very little better than that of the angle of a redoubt, with this disadvantage, that the defect exists equally throughout the whole circumference. An enemy, in order to attack the weakest part of a redoubt, is obliged to direct his march immediately against the angle, and consequently obstacles may be applied to obstruct his approach. A gun may be placed at the angle, which would render the access extremely dangerous: this cannot be done in the circular fort, for the ground being equally practicable on all sides, it is uncertain where the gun ought to be placed.

From these considerations, it appears to me that a circular work, so far from being preferable to all others, is very seldom so good, and ought only to be made use of in particular situations, as for example, to fortify a hill, the form of which is nearly round.

TRANSLATOR.

For

For example, for 500 men and two guns,

To the number of men = 500

Add 2×10 = 20

Their sum = 520 is the number of feet in the circumference.

2. The circumference being thus obtained, the radius will be found by the following proportion:

$$314 : 50 :: 520 : \frac{520 \times 50}{314} = 82 \text{ feet nearly.}$$

§ 126.

MANNER OF TRACING A CIRCULAR FORT UPON THE GROUND.

In order to mark out a circular fort upon the ground (Pl. 6, fig. 2.)

1. Drive a picket at the centre, *c*.
2. To this picket, fasten one end of a cord, the length of which is equal to the computed radius of the fort; and with the other end, *a*, describe a circle upon the ground. This must be traced as in § 73.
3. The lower thickness of the breastwork, *a b*, is then added to the length of the cord, and another circle is traced with the lengthened cord, *c b*.
4. The length of the cord is again increased by the breadth of the berme, *b d*, and a third circle described with radius, *c d*.
5. Lastly,

5. Lastly, the upper width of the ditch, de , being added to the cord, a circle is traced with radius, ce , which determines the place for the ditch.

When the circular fort is thus traced upon the ground, its actual construction can certainly cause no further difficulty.

§ 127.

From what hath hitherto been said concerning the various kinds of forts, it is indisputable that the defence of square forts or redoubts is in every respect very defective: they are notwithstanding more in use than any others. Many attempts have indeed been made to remedy these defects as much as possible, and to make such dispositions that the garrison may be enabled to defend the whole of the neighbouring ground conveniently, and without being obliged to fire in an oblique direction. The Chevalier Clairac in particular, has proposed for this purpose, that the breastwork, instead of being carried on in a right line, should be cut in the manner shewn by Pl. 6, fig. 3. ; and it is conceived that the soldiers placed in these cuts, which the inventor calls CREMAILLES, can fire with equal facility either in the direction ad , ae , or af .

When time and other circumstances admit of the construction of such cremailles, the advantage they afford cannot be denied.

§ 128.

CALCULATION OF THE SIZE OF A REDOUBT.

To find the length of the sides of a redoubt to contain a given number of men and field pieces, it is only necessary to determine, as in § 70 and 71, the number of feet which the troops require, and likewise the number necessary for the guns. These two numbers added together give the length of the four sides in feet, which divided by four, will be the length of each side.

For example, to construct a redoubt for 500 men and two guns: the length of the four sides is 520 feet (§ 125.), consequently $520 \div 4 = 130$ is the number of feet for each side.

§ 129.

CALCULATION OF THE INTERIOR SPACE.

When the garrison of a redoubt is not only to defend it, but likewise to dwell within it; as soon as the sides are found, it is also necessary to compute its area, which will determine whether there is sufficient space within the redoubt to afford proper lodging for the soldiers. A person who understands geometry can have no difficulty in finding this area: but to know whether it is sufficiently large, it must be observed that every soldier requires at least a space of 18 square feet, and a gun with its appurtenances 216 square feet.

Now,

Now, supposing the length of each side of a redoubt containing 500 men and two guns, to be 130 feet (§ 128.), its area will be 16,900 square feet.

But 500 men take up $500 \times 18 = 9000$ square feet,

And two guns require $2 \times 916 = 1832$ square feet,

Therefore the men and guns } occupy only 9432 square feet,

and consequently the area of the redoubt (§ 128.) is sufficiently large.

§ 130.

If a similar computation be made for a redoubt to contain 50 men and one gun, it will be found that its area is 225 square feet; which is barely sufficient for 12 men.

Again, the area of a redoubt for 100 men and two guns is 900 square feet; which will not contain more than 50 men.

The area of a redoubt for 200 men and four guns is 3,600 square feet, therefore this is merely sufficient for the men. Hence it follows,

1. That when troops are to be formed two deep, and the length of the sides of the work is determined according to the preceding rules, the interior space will never be large enough to lodge the men, unless the garrison consists of at least 200: but where there are more than that number, it is al-

ways sufficiently capacious for the accommodation of the garrison.

9. That when a redoubt is to be constructed for less than 200 men, who are also to be lodged within it, the work must be so planned that the interior space may be sufficient for the garrison to be lodged therein, even though the extent of the breastwork should become so great that it can only be manned by a single rank.

These maxims are not confined to redoubts, for if the same calculation be made with regard to any other forts, either of more sides, or circular; it will always be found that when the men are to be formed two deep, the interior space is not sufficiently large unless the number of men composing the garrison is at least 200.

§ 131.

MANNER OF TRACING A REDOUBT UPON THE GROUND.

It is very easy to trace a redoubt upon the ground.

As soon as the situation of one side of the redoubt is determined, a cord, ab , (Pl. 6, fig. 4.) of the same length as it is intended the side shall be, is stretched in a straight line, and the ground thereby marked out. The perpendiculars, ac and bd , are then erected, and made each equal to the side of the redoubt: this likewise regulates the side,

cd .

c d. If these perpendiculars are erected merely by the eye, it is proper to examine whether the distance from *c* to *d* is equal to the side of the redoubt. Should there be a material difference the perpendiculars must be revised, and the error corrected: after which the lines, *a c*, *c d*, and *b d*, are traced.

A redoubt may also be marked out upon the ground in the following manner:

As the proportion which the side, *a b* (Pl. 6, fig. 5.) of a square bears to its diagonal, *b d*, is nearly as five to seven; the length of the diagonal of a redoubt may be found from the given length of its side.

For example, if the length of the side is 80 feet,
 $5 : 7 :: 80 : \frac{80 \times 7}{5} = 112$ feet for the length of the diagonal.

Two stakes are then fixed at *b* and *d*, so that their distance asunder may be equal to the diagonal. To these stakes are fastened the two ends of a cord, the length of which is double that of a side of the redoubt. The middle of the cord is then taken hold of, keeping both sides of it equally stretched out, which determines the point, *a*; and in like manner the point *c* on the other side is found. Lastly, the ground is cut out along the lines, *a b*, *b c*, *c d*, and *d a*.

§ 132.

CALCULATION OF THE DITCH.

The interior line being thus determined, it is now to be surrounded by a breastwork and ditch. This is executed in the same manner and upon the same principles as I have shewn in the foregoing chapter, relative to a breastwork in general, thrown up in a straight line. The only new circumstance which occurs to be noticed and examined here, is the computation of the ditch.

As the ditch of a redoubt (Pl. 6, fig. 6.) and of every regular fort is carried around the outside of the work, and is necessarily longer than the breastwork, it is evident that if no more earth is to be taken from the ditch than is requisite for the formation of the breastwork, the profile of the ditch cannot be equal to that of the breastwork. On the contrary, in this case the solid content of the entire breastwork of one side of the redoubt or fort, must be calculated, which content divided by the mean length of the ditch $\frac{f+gb}{2}$ in its front, gives the area of the profile of the ditch, from which a competent breadth and depth may be found as before in § 42. In order to obtain the solid content of the breastwork of one side, its profile must be multiplied by its mean length $\frac{ab+cd}{2}$.

§ 133.

In a redoubt, because in the right angled triangle $b k d$, (Pl. 6, fig. 6.) the angles, b and d , are each 45° , $k d$ is equal to $b k$, and for the same reason $c i = a i$: consequently the length $c d$, of the outside of the breastwork, is found by adding twice its breadth to the interior length, $a b$.

For example, if $a b = 96$ feet, and $b k = 14$ feet; then is $c d = 96 + 14 \times 2 = 124$ feet. And the mean length of the breastwork is $\frac{124 + 96}{2} = \frac{220}{2} = 110$ feet.

In the same manner may be found the length of the counterscarp of the ditch, $g h$, by adding twice its breadth to the length of the scarp, $e f$. But the length of the scarp is equal to the outer length of the breastwork added to twice the breadth of the berme. If therefore, for example, the breadth of the berme is two feet, and that of the ditch 12 feet; then will the length of the scarp be $124 + 4 = 128$ feet; and the length of the counterscarp, $g h = 128 + 24 = 152$ feet: consequently the mean length of the ditch is $\frac{128 + 152}{2} = \frac{280}{2} = 140$ feet.

The further computation of the ditch will clearly appear from the foregoing rules, and is easily found by geometrical principles.

§ 134. When

§ 134.

When the principal line of the redoubt is traced upon the ground (§ 131.); and the rest of the dimensions are computed and settled; the several lines must accordingly be marked out on each side of the redoubt, in the manner explained in § 74. It is customary to round off the counterscarp of the ditch at the angles, with a curve *pr*, (Pl. 6, fig. 6). This curve is described by means of a picket fixed at *e*, to which is tied a cord, the length of which is equal to the breadth of the ditch.

As there must be an entrance into the redoubt its situation must likewise be determined. If guns are to pass through the entrance, it ought to be at least 12 feet broad, and should at all times be placed on that side of the redoubt the most secure from an enemy's attack.

§ 135.

CONSTRUCTION OF THE REDOUBT.

The actual construction of the redoubt, with every thing that can be applied to strengthen it, is performed according to the rules so fully explained in the foregoing chapter. It is only necessary here to shew the manner in which the *cremaillles* are traced, and the best method of constructing them.

Let

Let $a b$ (Pl. 6, fig. 7.) represent the interior side of the breastwork of a redoubt. Make ac , cf , &c. equal to 12 feet. Each of these small lines, ac , cf , &c. then becomes the diagonal of a redoubt, upon which the half redoubts acd , cef , &c. are described in the manner shewn in § 131.

Now, as the diagonal of a redoubt is to its side, as seven to five, each side of these half redoubts will be about eight feet and an half long. Therefore if the ends of a cord, 17 feet long, be fastened at a and c , and the middle of it stretched out, the point d will be found. And if the same operation be repeated at each of the lines cf , &c. all the cre-mailles will be determined.

With respect to the dimensions of the diagonals of these cre-mailles, they may be altered at pleasure.

When the breastwork is to be constructed according to the figure of the cre-mailles, they may be formed with a revetement either of sods, fascines, or, best of all, with hurdle-work.

§ 136.

ENTRANCE OF THE REDOUBT.

There are various circumstances to be observed with respect to the entrance of the redoubt.

In the first place, it must be perfectly covered in the rear, by a breastwork, A (Pl. 6, fig. 6.) called a TRAVERSE: otherwise the enemy might fire directly upon the garrison through this opening;

ing; and for the same reason the length of the traverse must be something greater than the breadth of the entrance. In order that every thing which is to come into the redoubt may pass freely by the traverse, its distance from the entrance should be at least equal to the breadth of the entrance. The earth for the formation of the traverse is taken either from the main ditch of the redoubt, or from a small ditch made immediately in front of the traverse: and as there is no reason to apprehend a powerful attack upon the traverse, its profile need be but very weak: at the utmost about eight feet thick. The manner of marking out the traverse, and its actual construction, can cause no further difficulty.

It is customary to fix one or two rows of chevaux-de-frise immediately in the entrance; and trous-de-loup, and an abattis may be placed advantageously in front of it. Precautions must in this case be taken that a free passage for the garrison to march out is preserved, and that our own troops may be enabled to enter without difficulty.

§ 137.

CANNON IN THE REDOUBT.

In every fort, and consequently in a redoubt, the guns must always be placed where their effect against an enemy may be the greatest. Therefore, for example, if the enemy can approach our redoubt only by narrow roads, the guns should be so disposed

as to enfilade these roads. In this case they ought to fire through embrasures, by which means they are better secured from the enemy's artillery. But when the enemy can attack us on all sides, it is most adviseable to place the guns en-barbette, at all the angles of the redoubt. If the elevations made for this purpose are sufficiently long and broad, the guns may be laid so as to fire upon the enemy in all directions. See Pl. 7. *

§ 138.

BLOCK-HOUSE IN THE REDOUBT.

When the redoubt is very large, if we expect a long abode within it, and there is a sufficiency of time and materials, a building of timber may be erected in the middle of the work. This is called a BLOCK-HOUSE, and serves to shelter the garrison, and especially the guard, from bad weather. To prevent the enemy's seeing and firing upon the blockhouse, it is sunk two or three feet below the horizontal ground; and in order that the shells from his howitzers may not so easily break through it, it is covered with beams, upon which earth and sods are heaped for a thickness of some feet.

* It may be proper here to observe, that in regulating the length of a work, when a gun is to be placed en-barbette at an angle of it, the usual allowance of 10 or 12 feet is not sufficient; but twice the length of the elevation formed for this purpose, or from 36 to 40 feet must be added to the length of the breastwork, for each gun disposed in this manner. TRANSLATOR.

§ 139.

HALF REDOUBTS, OR FLECHES.

When a post is covered in the rear, either by a village, a wood, a river, &c. and consequently that we are certain an attack cannot be made from that quarter, it is usual to construct only half redoubts instead of redoubts. Such a work, *abc*, (Pl. 6, fig. 8.) is termed a FLECHE, or ARROW, and the two lines, *ab*, *bc*, which form the salient angle, are called THE FACES.

§ 140.

The following circumstances are to be observed concerning fleches:

1. The length of the face of a fleche to contain a certain garrison is easily calculated. The number of guns and men determines the length of the two faces in feet, and consequently half this will be the number of feet in each face.

For example, the two faces of a fleche to contain 120 men, and two guns, will be 140 feet in length, (§ 70.) and therefore each face will be 70 feet.

2. The angle made by the faces of a fleche need not be a right angle, nevertheless it should not be either much less or much greater, and on no account less than 60° , as the interior space towards the angle of the fleche

would

would thereby be a great deal too narrow.

When the situation of the faces with respect to one another is determined, it is easy to trace the entire fleche upon the ground.

3. The opening, *ac*, behind such a work is called its GORGE. If there is reason to fear an enemy's taking us by surprise through the gorge, it may be completely closed by a row of palisades.

4. Two flanks, *ad* and *ce*, (fig. 9.) are frequently made at right angles to the two sides of the fleche, in order to defend the faces *ab* and *bc*. Guns may be placed upon these flanks; but as they are exposed to the enemy's fire, they ought to be covered by two breastworks, *df* and *eg*.

5. The actual construction of a fleche must be sufficiently known from the former rules.

§ 141.

OTHER FOUR-SIDED FORTS.

It is by no means necessary that the form of a four-sided fort should be a perfect square, but may be any other quadrilateral figure: and frequently the situation of a post requires an irregular figure; in which case it would be erroneous to construct a square work.

All other kinds of four-sided forts however are calculated and erected entirely according to the rules explained concerning redoubts.

§ 142. PEN-

§ 142.

PENTAGONAL FORTS.

Forts of five and six sides are likewise computed and constructed upon the same principles, and in the same manner as redoubts. However, as the method of marking them out upon the ground varies a little from that respecting redoubts, I will here explain the best mode of tracing such works.

When the length of one side of a regular pentagonal fort is determined according to the principles which have been already so often given, the length of the diagonal corresponding to that side may be calculated by trigonometry.

Or, as the side, ab , (Pl. 8, fig. 1.) of a regular pentagon is to its diagonal ac , nearly as five to eight; the length of the diagonal may be more speedily found from this proportion.

For example, to construct a five-sided fort for 500 men, and four field-pieces. The entire circumference is 540 feet, and therefore the length of each side will be 108 feet. Hence $5 : 8 :: 108 : \frac{108 \times 8}{5} = 172$ feet nearly, for the length of the diagonal. Therefore,

1. Upon the ground trace a line, ab , of the same length as the side of the fort.
2. Take a cord equal in length to twice the diagonal, ac . Fasten the ends of the cord at a and b , and lay hold of the middle, keeping it equally stretched out on both sides: this will determine the point c .

3. In

3. In like manner, by fixing a cord twice as long as the side ab to a and c , the point e will be found; and the point d may also be obtained by a similar process.

4. The earth being then cut out along the lines bd , dc , ce , ea , the principal line of the five-sided fort will be traced upon the ground.

§ 143.

HEXAGONAL FORTS.

When a fort of six sides is to be marked out upon the ground: having first calculated the length of the side according to the strength of the garrison,

1. Trace the line ab (Pl. 8, fig. 2.) equal to the side.

2. Upon this line, ab , by means of a cord equal to twice the length of the side, describe an equilateral triangle, abc , in the manner shewn before.

3. With the same cord, upon the line bc , construct the triangle bcd , and proceed in the same manner for the triangles acg , cde , and cef .

4. Lastly, trace the lines bd , de , ef , fg , and ga , and they will form the circumference of the hexagonal fort.

§ 144.

STAR FORTS.

The forts which have been hitherto explained have not any flank defence. In order that this advantage may likewise be procured, every side must be equally broken, so as to make a re-entering angle: or in other words, star forts must be constructed. For this purpose,

1. Divide the side ab into two equal parts in the point c . (Pl. 8, fig. 3, 4, and 5.)
2. At c draw the perpendicular cd , and in the square make it equal to one-eighth of the side ab ; in the pentagon equal one-seventh, and in the hexagon equal one-sixth of the side.
3. Lastly, draw the lines ad and bd , which will be the faces of the star fort, forming a re-entering angle.

The flank defence of these faces is indeed but very small, (§ 114.) and would be better if the perpendicular cd was longer; but the salient angles a and b would then be decreased: and as these angles ought never to be less than 60° , it will be evident, from the principles of geometry and trigonometry, that the perpendicular cd cannot be greater than is here given.

§ 145.

The whole flank defence which is obtained in this manner, is in fact of no great signification, and

and it is nearly indifferent whether a star fort of this nature is constructed, or a fort with salient angles only, and the defects attached thereto. However the flank defence of star forts may be improved by placing a fleche at every re-entering angle. For this purpose, divide ad and bd (Pl. 8. fig. 6.) each into three equal parts. Set off one-third from d to e and f , and upon ef describe a fleche egf . The breastwork is then constructed according to the direction of the lines ae , eg , gf , and fb ; which thereby afford one another a good flank defence.

§ 146.

REMARK.

To conclude—the following observations concerning all star forts demand attention.

1. As the circumference of the fort is considerably increased on account of the salient and re-entering angles, especially in that kind last explained (fig. 6.); this circumstance must not be neglected in the calculation.
2. The entrance of a star fort should be formed in a re-entering angle on the side most secure, or in one of the fleches; and must be covered in the same manner as that of a redoubt.

and it is nearly indifferent whether a star fort of this nature is constructed for a fort with salient angles only, and the defects attached thereto.

§ 147. FORTS WITH BASTIONS.

Finally, according to the proposals of many engineers, large field forts may likewise be designed and executed with advantage in the following manner.

1. Divide the side ab (Pl. 8, fig. 7.) into two equal parts in the point c : draw the perpendicular cd , the length of which is determined as in § 144, and through d draw the lines ad , bd , of an indefinite length.
2. Divide ad , and bd , both into three equal parts, and set off one-third from d to e and f .
3. From e draw eg perpendicular to bd produced, and from f draw fh perpendicular to ad produced.
4. Lastly, draw the line gh , and the breastwork is then constructed in the direction of the lines ae , eg , gh , hf , and fb .

The works $geaeg$, at the angles of the fort, are called **BASTIONS**. The breastwork gh , between the two bastions, is named **THE CURTAIN**. A bastion consists of two **FACES**, ae , and two **FLANKS**, eg . The angle, cae , is called **THE FLANKED ANGLE OF THE BASTION**; the angle aeg , **THE ANGLE OF THE SHOULDER**; and the angle egh , **THE ANGLE OF THE FLANK**. The line ab is termed **THE EXTERIOR SIDE OF THE POLYGON**; the

the lines *ah*, *bg*, THE LINES OF DEFENCE; the line *kg*, THE DEMI-GORGE OF THE BASTION; and the line *ka*, THE CAPITAL.

§ 148.

This method of fortifying is properly borrowed from permanent fortresses; but I have taken notice of it here, as being sometimes made use of in the field.

It is evident by inspecting this figure, that the defence is much more perfect than that of all the others which have been explained. There is not a single point throughout the circumference of the fort, which has not a flank defence, as well as its own front defence; and the flanks, *eg* and *fh*, which principally defend the weakest parts, or the faces, *bf* and *ae*, are so disposed that the enemy cannot well discern them, and still less fire upon them with any impression, before he feels their effects in a most powerful manner.

CHAPTER V.

OF THE APPLICATION AND USE OF THE WORKS DESCRIBED
IN THE FOREGOING CHAPTER.

§ 149.

THE works which have been treated of in the foregoing chapter, are made use of to fortify a camp, a village, a hill, a bridge, a single house, a small town, the banks of a river, a sea-coast, or the like. It is therefore necessary to explain the method of applying them to all such cases.

§ 150.

METHOD OF FORTIFYING A CAMP.

It may be said that a camp is fortified, if it is entirely surrounded by a breastwork, erected conformable to the figure of the camp: but in that case, there would not be any flank defence throughout the whole circumference; and consequently to obtain this advantage it must be fortified in a very different manner.

The most simple scheme for this purpose is as follows.

1. At distances of about 200 yards from one another, fleches are erected, sufficiently capacious to contain 250 or 300 men: these fleches are termed REDANS.

2. Between

2. Between every two such works, a breastwork is thrown up in a straight line; or in other words, the redans are connected by a curtain.

3. The entrances of the camp are made in these curtains; and are covered either by a traverse in the rear, or a fleche in front.

The breadth of the entrances should be at least 16 feet.

§ 151.

It appears perfectly natural to adopt the foregoing method of fortifying a camp, if we only consider the usual mode of encamping, and the manner in which the camp-guards are disposed. It is customary to place the several guards opposite the centres of their respective battalions; and each of these guards covers itself by a fleche; so that if the front of a battalion takes up about 200 yards, this will likewise be the distance of the redans from one another; which are afterwards joined together by a breastwork.

By means of these redans, the whole intrenchment receives a flank defence; and a cross fire is obtained in front of the curtains. Moreover each redan may be defended by those adjacent to it, and therefore they should never be much further asunder than 200 yards. (§ 118.) If the distance between two guards exceed that length considerably, one or two redans must be constructed between them.

§ 152. SIZE

Between every two such works, a breastwork
 § 152.
 is thrown up in a straight line; or in other
 words, **SIZE OF THE REDANS.**

Agreeable to the principles of M. Vauban, I have regulated the number of men for the defence of a redan, at 250 or 300; therefore if they are drawn up two deep, the length of the two faces of the work will be from 250 to 300 feet, or of each face from 125 to 150 feet. This length will also serve when cannon are to be placed in the redan, only decreasing the number of men, at the rate of 10 men for each gun.

The angle made by the faces of a redan is optional; but it is customary to adhere nearly to a right angle: for although the flank defence of the curtains and neighbouring redans is better the more acute the angle is, nevertheless, to preserve a good interior space, and in order that two pieces of cannon may be placed conveniently in the angle, it ought not to be much less than 90 degrees.

The size of the gorge is determined by the length of the faces, and the measure of the angle included by them: when this is about a right angle, the proportion of the face to the gorge is nearly as five to seven (§ 131.); therefore if the face of the redan is 125 feet, or nearly 42 yards, the length of the gorge will be about 59 yards.

§ 153. PROJECT

axis .231 §

before the curtain which has no flank defence. The ground in front of the angle of the redan, may indeed be very well defended by means of the artillery. **PROJECT FOR AN INTRENCHMENT WITH REDANS.**

To trace an intrenchment as described above: (Pl. 9, fig. 1.) In a right line set off 200 yards from *A* to *B*, from *B* to *C*, &c. and from these points make the demi-gorges *Aa*, *Ab*, *Bc*, *Bd*, &c. each equal to about 30 yards: lastly, from the points *a* and *b*, *c* and *d*, &c. with a radius of 42 yards, describe arcs intersecting in *g*, *h*, &c. so will *agb*, *bhc*, *chd*, &c. represent three redans, and *bc*, *cd*, the curtains between them: only being carried on in a straight line, it should form a salient angle. For this purpose, join the points *a* and *b*, *b* and *c*, &c. by a right line, and divide § 154.

REFLECTION UPON THE FOREGOING PROJECT.

As we here consider the soldier to fire directly before him, the troops placed behind *gb* defend the space *bgkl*, which is a rectangle, the length being the range of musket shot *bl*, and breadth the face *bg*.

In like manner an equal space *cmnh* is defended from the face *ch*, and the space *bcpo* from the curtain *bc*: consequently the strongest fire from this intrenchment is in front of the centre of the curtain, and about 100 yards distant from it. There remains however a great extent of ground immediately in front of the angle of the redan, without any defence; and a considerable triangle before

before the curtain which has no flank defence. The ground in front of the angle of the redan, may indeed be very well defended by means of the artillery placed in the angle; but I have shewn, § 118, that in general the chief dependance must be on the defence obtained from musketry. The above design for an intrenchment is therefore very defective, and affords but a slight defence.

points make the demi-gorges A, A, B, C, D, &c. each equal to 25.55 yards: lastly, from

IMPROVEMENT OF THE FOREGOING PROJECT.

42 yards, describe arcs intersecting in C, &c. This intrenchment may be much improved by only breaking the curtain; that is, instead of its being carried on in a straight line, it should form a salient angle. For this purpose, join the points *a* and *b*, (Pl. 9, fig. 2.) by a right line, and divide this line into two equal parts in the point *e*; lastly, draw the line *cd*, *ce*, which will be the two parts of the broken curtain.

By this scheme the angle of the redan receives a very good cross fire from the curtains; and it is evident from inspection, that the defence is altogether much more perfect than in the foregoing project. The redans may likewise without any disadvantage be placed further asunder, and yet the fire from the curtain will cross sufficiently in front of the angle*.

the curtain, and about 100 yards distant from it. Clairac makes the distance between these redans 150 fathoms.

AUTHOR.

signify a defence, and a considerable triangle before

§ 156. Upon

§ 156.

Upon examination of the defence of the intrenchment, according to this improved scheme, it will appear that the entire circumference is composed of salient and re-entering angles alternately. These angles are of different dimensions; but it is easy to make them all equal, as well as the lines which form them; by which means the construction of such an intrenchment, and the method of marking it out upon the ground, is rendered much easier.

On the right line, *ag*, (Pl. 9, fig. 3.) set off 100 yards from *a* to *b*, from *b* to *c*, &c. and at the points *b*, *d*, &c. erect the perpendiculars *bh*, *dk*, &c. each equal to 80 or 100 yards: draw the lines *ah*, *hc*, *ck*, *kg*, &c. which will determine the breastwork of the intrenchment.

The dimensions here given are conformable to the principles of fortification hitherto established; but in certain cases a deviation from them will not be attended with any disadvantage.

§ 157.

INTRENCHMENT WITH BASTIONS.

The above project for intrenching a camp may be further improved, by constructing regular bastions at proper distances, instead of redans.

The plan of such an intrenchment is traced in the following manner.

T

Upon

Upon the line ab , (Pl. 9, fig. 4.) set off 300 yards from a to c , from c to b , &c. Divide ac , cb , into two equal parts in the points d and e , and draw the perpendiculars, df , eg , each equal to 50 yards; Draw the lines af , cf , cg , bg , &c. and produce them indefinitely beyond the points f and g : on these lines take ah , ci , ck , bl , each equal to 70 yards, for the faces of the bastions. From h draw hm perpendicular to cf produced, and from i draw in perpendicular to af produced; then will hm , in , be the flanks: in like manner draw ko and lp . Lastly, draw mn and op for the curtains, which completes the plan of the breastwork.

§ 158.

REFLECTION UPON THE FOREGOING INTRENCHMENT.

By this project for an intrenchment with bastions, (Pl. 10, fig. 1.) the breastwork undoubtedly receives a tolerably good defence every where; nevertheless it has some defects.

1. The ground in front of the faces of the bastions, is by no means so well defended as that immediately before the curtain; and an enemy designing to attack a bastion, may approach very near it before he comes under our fire: for as the face of the bastion is defended only from the flank, which does not exceed about fifty yards in length, it is plain that the enemy may advance within 50 yards of the bastion, without the danger of losing a man.

a man*. These bastions have therefore, not sufficient defence.

2. Again, when the enemy has got into the ditch in front of the face, he is no longer exposed to the fire of the flank.

For as the ditch runs parallel to the face, flank, and curtain, the ground opposite the shoulder of the bastion prevents the soldiers posted at the flank, seeing the ditch in front of the face.

§ 159.

IMPROVEMENT OF THE FOREGOING INTRENCHMENT.

The defects alledged above respecting the intrenchment with bastions, may be remedied in the following manner.

1. The first fault may be removed by breaking the curtain, so as to form a salient angle, mfn , (Pl. 10, fig. 2.) instead of a straight line, mn ; by which means the bastions gain the advantage of a much better defence, as the figure shews. The ground in front of the curtain, indeed, is not so well defended; nevertheless the fire is better divided throughout the whole circumference of the intrenchment; and the cross fire before the curtain still

* Although not clearly expressed, it is evident that the author alludes to the ground immediately in front of the salient angle, and supposes the enemy to advance towards that point.

TRANSLATOR.

remains so strong that an enemy would hardly direct his attack against that part.

2. In order to obtain a defence for the ditch in front of the face, it is only necessary to cut away the ground opposite the shoulder, and give it such a slope that the bottom of the ditch may be seen from the flank. This is shewn in the plan (Pl. 10, fig. 3).

§ 160.

INDENTED INTRENCHMENT.

Another good method of intrenching a camp by means of salient and re-entering angles, is as follows.

Upon the line ak (Pl. 11, fig. 1.), set off 120 yards from a to b , from b to c , &c. and at the points, b , c , &c. erect the perpendiculars, bd , ce , &c. each equal to about 30 yards. Draw the lines, ad , be , &c. and make bf , cm , &c. equal to about 10 yards. Lastly, draw df , em , &c. and the breastwork is completed.

This is called an indented intrenchment. Its defence, as appears from the figure, is very good, and which is best of all, every where equally strong.

§ 161.

ADVANCED DITCH.

When a camp is to be intrenched by any method whatever, we should endeavour, as much as time, the

the nature of the ground, and other circumstances permit, to employ all possible means of impeding the enemy in his attempts to climb the breast-work. We have already examined and explained in the second chapter, the manner of executing the various obstacles for this purpose, except the advanced ditch; which therefore remains to be noticed here.

I have shewn (§ 56.) that though there may appear to be great advantage derived from an advanced ditch, it is notwithstanding very detrimental according to the usual construction; as it has no defence. I will now therefore explain the method by which this defect may be remedied.

In order to procure a good defence for an advanced ditch, the same measures must be pursued respecting the re-entering angles, *a* and *b* (Pl. 10, fig. 3.), as were adopted with regard to the ditch before the face of the bastion (§ 159.); that is, the earth must be cut away so as to form a very great slope. The advanced ditch is thus open to the flank, and its whole length enfiladed from it.

It is true this slope affords the enemy an easy ascent from the ditch; however, from the manner in which the fire may be directed against it, and especially if it can be enfiladed by a gun, this convenient passage will be rendered extremely dangerous; and certainly not prove of any advantage to him.

§ 162

ENTRANCES OF THE INTRENCHMENT.

I have not as yet taken into consideration the passages into the intrenchment; and shall now therefore make the following remarks concerning them.

1. The entrances must always be placed where there is the best cross-fire: for this purpose in an intrenchment with redans or bastions, they are made in the middle of the curtain; but in an indented intrenchment, they are formed in the salient angle.
2. Through these passages, sallies are frequently made upon an enemy in his attack, or when driven back; for which reason they must never be too narrow, that the troops may not be delayed in marching out. Their breadth should be at least 16 feet.
3. For the reason given above, it is likewise proper to make several passages into the intrenchment; that the troops may be enabled to march out in a great number of columns, and thereby more speedily form into order of battle, to attack the enemy. There would not be too many if they were placed at 350, or 400 yards asunder.
4. The entrances are secured and covered in the same manner as was shewn (§ 136.) with respect to that of a redoubt.

§ 163. SPACE

§ 163.

SPACE BETWEEN THE CAMP, AND THE INTRENCHMENT.

A certain space must be left between the camp and the intrenchment, that the troops may be able to make the necessary movements for the defence of the breastwork, without being obstructed by the tents. Two hundred yards are generally allowed for this purpose, which is the usual distance of the quarter-guards from the camp; and is likewise sufficient for the manoeuvres of the troops without being incommoded. This rule however is not universal, as cases sometimes occur where it is necessary to increase the distance between the camp and the intrenchment; but it should never be less than that given above.

§ 164.

CONSTRUCTION OF THE INTRENCHMENT.

It is not necessary to enter into a particular and extensive discussion, concerning the actual construction of the intrenchment of an entire camp. When the extent of its circumference has been measured, and the mode in which it is to be fortified determined, it is easy from the principles laid down in the third chapter, concerning the construction of a breastwork in general, to ascertain the requisite quantity of materials, and the time taken

taken up in preparing them; as likewise the number of workmen, and the time in which they can complete the work. The method of performing each particular kind of work is also known from the preceding instructions.

As it is difficult to procure a sufficient number of workmen, to complete such an extensive intrenchment in the most speedy manner, it generally proceeds slowly. Experience teaches us that it requires at least 14 days to bring the entire work to a state of perfection.

§ 163.

FORMATION OF A WORK BY MEANS OF BAGS FILLED WITH EARTH.

It is frequently of great importance in the field, to complete a good intrenchment in a very short time. The manner of forming the breastwork so amply explained in the third chapter, always requires a considerable time; even when as many workmen are procured, as can be employed at once. It would therefore be of great service to discover some method of erecting the breastwork, in a more speedy manner than that usually practised. M. Bonneville, in his remarks upon Count Saxe's military art, has made the following proposal for that purpose.

The whole work is to be composed of small bags filled with earth. These bags to be made of coarse cloth; and sufficiently large to contain about a

cubic foot of earth when tied up. The diameter will then be a foot, and length one foot and an half; and to prevent their being injured by wet, they should be dipped in tar.

To erect a work by means of these bags, it must first be marked out upon the ground as usual. A sufficient number of bags are then filled with earth, and securely tied. They are afterwards arranged close together, and upon one another, agreeable to the figure of the work.

§ 166.

ADVANTAGES OF THE FOREGOING SCHEME.

This method of erecting a work has the following advantages:

1. A greater number of workmen may be employed, than by the usual mode: for as it is indifferent from whence the earth is taken to fill the bags; the men may disperse over the ground; by which means the work will be much sooner finished than by the common method.

2. The time and labour taken up in cutting sods, binding fascines, and the whole formation of the interior slope of the breastwork, and cheeks of the embrasures, is saved: for if these bags are properly disposed, the work will be sufficiently solid.

3. A man may very conveniently fill 30 bags in an hour: therefore if the solid content of

the breastwork is about 27,280 cubic feet, and 1000 men are employed, they can easily fill the 27,280 bags in the hour. And if another hour is allowed for placing and arranging the bags, the entire intrenchment, as far as relates to the earth-work, will be completed in two hours.

§ 167.

DISADVANTAGES OF THE FOREGOING SCHEME.

The above manner of erecting a work by means of bags filled with earth, is attended with the following disadvantages.

1. A work of this nature has no ditch; consequently it is easy for an enemy to approach and climb it; and this defect cannot be remedied by palisades, fraises, or chevaux-de-frise. With respect to trous-de-loup, an advanced ditch, an abattis, or fougasses in this case; if there is sufficient time for the construction of any of these, the whole work might for the same reason be carried on in the usual manner.
2. Another difficulty arises from the astonishing number of bags, which even a moderately extensive intrenchment requires. I will suppose it to be 12,000 feet long. Now if the profile of the breastwork contains 77 square feet (§ 43.), 924,000 bags will be necessary. It must also occasion

a great expence to provide these bags, and to replace such as must unavoidably be lost or spoiled in using them. A great number of carriages must be employed to transport them, and many other inconveniences would thence accrue.

§ 168.

**FURTHER CONSIDERATION OF THE FOREGOING
SCHEME.**

The foregoing method of forming a breastwork may nevertheless at times be very useful, as it is perfectly practicable, and may be executed with scarcely any difficulty. It should however be adopted only in small intrenchments; and where great haste is indispensably necessary. For example, when a landing on a coast is effected, and an attack expected every moment; the troops who first land may with the greatest propriety have recourse to this scheme, to secure and cover themselves.

The second difficulty mentioned in the preceding paragraph is here entirely done away; and the first would exist equally if the usual manner was pursued: for where such great haste is required in the execution of the work, it is scarcely possible to establish palisades, fraises, &c.

§ 169.

INTRENCHMENT WITH LUNETTES.

All the foregoing methods of intrenching a camp have this defect, that the enemy is not exposed to its fire for a sufficient length of time. He may advance in tolerable security to within about 200 yards of the work, and can run through the remaining distance in a few minutes, if there are no further obstacles to oppose his progress. It would therefore be very advantageous in every intrenchment, especially when time and other circumstances will not allow us to employ additional means of keeping off the enemy, to make such dispositions as would cause him to be sooner, and consequently longer exposed to our fire. Folard has proposed for this purpose, that at a distance of from 80 to 120 yards in front of an intrenched camp, fleches should be thrown up, which have a covered communication with the main work, and are defended from it; and which are moreover in a state either to keep off the enemy entirely, or at least to fire upon him early in his approach: they are termed LUNETTES. Clairac gives two projects for an intrenchment of this nature, but it will be sufficient here to explain one of them.

§ 170. Upon

§ 170.

Upon the front of the camp to be intrenched, take ab (Pl. 11, fig. 2.) equal to 240 yards. Bisect it in c , and draw a perpendicular both inwards and outwards. From c to d set off 70 yards, and draw the lines ad , bd . From d set off 50 yards to e , and 36 yards to f and g , and draw the lines ef , eg . Lastly make ch equal to 120 yards, and ai , bk each 40 yards. Draw the lines hi , hk , and from h set off about 30 yards to l and m : then will hl , hm , be the faces of the lunettes.

According to this figure, the faces hl , hm , are defended from ai , and bk ; and af , bg , from ef , eg : the part nr fires in the direction ro , close to the lunette. There is no fire from the part rp , on account of the lunette in its front.

§ 171.

The communication between the lunettes and the principal work, is formed as follows.

1. The gorges of the lunettes are closed by palisades, to prevent being taken in reverse (Pl. 11, fig. 3).

2. A passage 10 or 12 feet wide, is made from the gorge of each lunette to the intrenchment. This passage is covered on both sides, either by palisades, or by a breastwork of earth. It is proper in either case to sink the

the passage a few feet below the ground, that the palisades or breastwork may not obstruct the fire from the main work. The height of the breastwork may be from four feet to four feet and an half from the bottom of the passage, in order that the soldiers may fire over it without a banquette.

3. The entrance of the intrenchment is covered by a traverse, around which the communication is carried, to render the passage perfectly secure.

§. 172.

REFLECTIONS UPON THE FOREGOING INTRENCHMENT.

By the method described above, we gain this advantage, that the enemy cannot approach the intrenchment until he has gained possession of the lunettes: but these works being very well flanked, are not easily carried; and may be defended to the last, as the retreat to the intrenchment cannot be cut off.

According to this project however, the lunettes are only 240 yards asunder; and if we suppose the front of the intrenchment to be in a straight line, the covered communications will be parallel to one another. In consequence of this, the troops posted in one of these passages must fire directly against another; and might thereby kill or hurt the soldiers within it. Clairac therefore recommends that the

the lunettes should be placed only opposite every second front of the polygon.

This kind of intrenchment is also very extensive, and requires a considerable time, and a great number of workmen for its construction; as well as a strong garrison for its defence: and therefore however excellent it may be in other respects, it ought never to be executed where any of these are wanting.

§ 173.

DEFECTS OF ENCLOSED INTRENCHMENTS.

All the intrenchments which have been hitherto treated of, are called enclosed intrenchments, the entrances being only small openings.

A great many people versed in military science, have been of opinion that this manner of fortifying is very defective; for as it obliges the troops to march out of the work nearly by single files, the enemy may be much bolder in all his motions, and should he be thrown into disorder in his attack, or even entirely driven back, he need have no apprehensions of being pursued by the garrison, or beaten in his retreat.

In this case he can rally very near the intrenchment, and may probably undertake another attack in better order, and with greater success. For this reason it would be much more advantageous to construct works in which the openings were of such dimensions that the army could at all times march out in order of battle.

§ 174. IN-

§ 174.

INTRENCHMENT WITH SINGLE REDOUBTS.

Agreeable to the opinion of several engineers intrenchments connected together in the manner of those described above, ought to be made use of only when we are weak, and that it is necessary to avoid a battle by all means whatever ; but on no account for the encampment of a whole army. In lieu thereof they recommend that single detached fleches, or, still better, that redoubts should be erected in front of the camp.

These works (Pl. 11, fig. 4.) should not be further asunder than 400 yards, nor less than 270, and ought to be sufficiently large to contain a garrison of 200 men. They should likewise be put into the best possible state of defence, according to the rules before laid down.

As these redoubts do not afford any flank defence to one another, a second row is formed behind the first. The best situation for this new row is found by producing the faces of the redoubts in the first row, and where they intersect will determine the gorges of those in the second row.

§ 175.

INTRENCHMENT WITH ENCLOSED FORTS.

If these redoubts were joined together by lines, they would form ANOTHER CONNECTED INTRENCHMENT WITH ENCLOSED FORTS.

This

This mode of intrenching a camp was formerly very usual, and when, instead of redoubts, regular bastions were constructed, their gorges were closed by a breastwork; from which it was conceived great advantage might be derived: for even though the enemy should gain a certain part of the intrenchment, he would still not be perfectly master of it, as the garrisons of the forts might hold out, and defend themselves for a considerable time.

On the other hand, should the enemy gain possession of one of these forts, he would be able to fire from it directly upon us; and would thereby be placed in a situation where he might more strongly oppose us: it is therefore seldom adviseable to intrench a camp by this method.

§ 176.

OF REGULAR AND IRREGULAR INTRENCHMENTS.

The several methods of intrenching a camp, which have been hitherto explained, may all be termed regular; as it has been supposed throughout, that the ground is so perfectly level, that the works may be constructed with the same regularity as they can be traced upon paper. This however very rarely happens in war; and it is proper now to examine and consider various particular cases, both with respect to the encampment of an army, and likewise the fortification of single posts of other descriptions, which frequently occur in the field. I shall therefore proceed to shew how

all these are to be executed, and begin by explaining the manner in which a hill, and a village may be intrenched, and placed in a state of security against the attack of an enemy.

§ 177.

METHOD OF FORTIFYING A HILL.

When a hill is to be fortified, its nature and situation must be perfectly ascertained; and in particular whether it is steep, or rises gradually.

The principal object with respect to steep hills, is to endeavour to render the small roads leading up them impassable; and the best method of performing this is to cut broad and deep ditches across the roads, in which palisades or chevaux-de-frise may be fixed.

If the summit of the hill is exposed to be fired upon from other heights, a breastwork must be thrown up: but otherwise there is no occasion for any regular intrenchment; and it is in this case sufficient to erect palisades, behind which the garrison may defend itself, even when the enemy has mounted the hill. In situations which require a regular breastwork, it is frequently advantageous to form the ditch behind the work.

If the hill is overgrown with wood, particular precautions must be taken that the enemy may not creep up it unobserved; and the most effectual means of preventing this is to cut down all the wood, and form strong abattis with it.

But when a hill rises so gradually that it may be ascended without difficulty, it must be intrenched with a breastwork in the usual manner; and all possible means must be applied to prevent the enemy's climbing the hill and breastwork.

§ 178.

When only a single hill is to be fortified, an enclosed fort may be constructed upon it: but if the height lies in the environs of an intrenched camp, or at a certain distance from our works, and that it is necessary to fortify it, to prevent an enemy's occupying it, and battering us from it; that side only which is turned towards the enemy, should be fortified. In the last case, the gorge of such a work should be closed by palisades; and attention must be paid to establish a secure communication between it and the works in its rear.

Lastly, with regard to the figures of all works upon heights: they must be adapted chiefly to the form of the ground; but we should always endeavour to obtain a good flank defence; which is the more easily accomplished, the more the hill naturally consists of salient and re-entering angles.

§ 179.

METHOD OF FORTIFYING A VILLAGE.

When a village is to be fortified, we should first consider its situation, and the nature of the houses.

With respect to the situation of the village, we ought to examine the advantages or disadvantages which we may derive from it; and diligently endeavour to increase the former, and diminish the latter. For example, if a hollow way leads to the village, by which an enemy might approach unobserved, it must be rendered impassable. If there are bushes in the neighbourhood they should be entirely cut down and removed, especially if they might prove of any benefit to the enemy. If a brook runs by the village we should examine whether it affords an opportunity of forming an inundation: if not we ought at least to destroy the fords. Particular consideration should be given to the heights which may probably be near the village. Should there be any so situated that the enemy might from thence overlook the village and batter it, unless we can include them within the intrenchment, it must be extremely difficult, if not impossible to make a good post of such a village.

§ 180.

With regard to the nature of the houses, we should examine whether they might be of any service in the defence, or not. Houses with walls of stone or brick, and tiled roofs are useful; but wooden buildings with thatched roofs are not proper, as they may be easily set on fire by the enemy. If it is essential that the village should make a considerable resistance, either the church and churchyard,

yard, or any convenient and advantageous building may be converted into a place of reserve, to which the garrison may retire when obliged to yield the village to the enemy. I shall hereafter explain the necessary preparations for this purpose.

§ 181.

The intrenchment of a village may consist either of a connected work, or of detached forts. In the former case any of the methods described above for the intrenchment of a camp, may be here applied.

The figure of the entire intrenchment depends upon that of the village, always striving to obtain a good flank defence. It may sometimes be advantageous to erect the breastwork behind the garden-hedges, for if they are only cut so as not to obstruct the fire of the troops, the enemy has thereby an additional obstacle to overcome before he can scale the work. The intrenchment however must never be too near the houses, because the enemy will endeavour to burn them, and we should therefore be obliged to abandon the work on account of the flames.

§ 182.

When there is not sufficient time for the formation of a connected intrenchment, redoubts, fleches, or works of any other figure may be erected in the circumference of the village; and should be disposed

disposed in such a manner that they mutually flank one another. As the enemy might easily pass between these detached works, and enter the village, the intervals ought to be particularly well secured. If the strength of the garrison will allow it, soldiers may be posted in these intervals, behind bushes and hedges, and thereby easily prevent the enemy's further advance. But if troops are wanting, other obstacles must be opposed. For example, a broad and deep ditch may be made from one fort to another: several rows of *trous-de-loup* may be dug between them: an *abattis* may be formed: palisades and *chevaux-de-frise* may be planted: or carriages may be placed with their shafts fixed into one another, and some of their wheels broken in two, &c.

§ 183.

When a village is of great extent, it frequently cannot be fortified throughout. In that case, only a certain part of it is intrenched as above, and separated from the rest by pulling down or burning the nearest houses. There should be a free space of at least 200 yards, between the intrenchment and the houses.

In this situation also a post may be established without the village, and regularly intrenched, to which the garrison may retire in case of an attack: but particular precautions must be observed not to be surprised in the village; and a secure covered
com-

communication must be formed between it and the work.

§ 184.

OF TÊTES-DE-PONT.

Having shewn the manner of fortifying a camp and village, I will now proceed to explain the method by which a bridge across a river, may be put into a state of security against the attack of an enemy, as this is a case which frequently occurs in war. The works which are thrown up for this purpose are called in general TÊTES-DE-PONT.

When there is little to fear from the enemy, it is sufficient to erect a fleche in front of the bridge (Pl. 12, fig. 1). The entrance is placed in one of the faces, and covered by a traverse. The interior space should be so large that the troops and every thing else which must pass the bridge, can move through the work conveniently, and without pressing.

The defence of this work is bad, as it has no flank; and moreover there is a great extent of ground in front of the salient angle, without any defence whatever. In this case therefore it would be better instead of the fleche to construct a work in form of semi-circle.

§ 185.

When there is more to apprehend from the enemy, a fleche with flanks may be formed. (Pl. 12, fig.

fig. 2.) These flanks are covered by a breastwork, extending from them backwards to the river, and in a direction parallel to the face of the fleche. The entrance is between the face and flank, and covered by a traverse. If the river is not too broad, the flanks may be thrown up on the opposite side, as fig. 3. At least the batteries for heavy artillery may frequently be placed there very commodiously.

§ 186.

As these works are altogether but small, and therefore do not afford any considerable defence; it is sometimes proper to erect larger works to cover a bridge: for example, when an army in face of an enemy, is to retire over it. By following the rules and principles hitherto given, it is easy to design such an intrenchment, according to the nature of the country, and the number of troops which can be furnished for its defence.

The fourth figure represents such a large tete-de-pont. The outer intrenchment serves to cover the retreat of a whole army; and the small works, *A* and *B*, will afterwards cover that of the garrison in the large intrenchment.

It is not necessary always to make choice of a connected intrenchment for this purpose, as a bridge may be covered by means of detached works. For example, redoubts may be formed in front of the bridge, so as to create a cross-fire, and mutually flank one another. This method appears to me

more

more advantageous for the retreat of a whole army, than an enclosed intrenchment.

§ 187.

METHOD OF FORTIFYING THE BANKS OF A RIVER.

The preventing an enemy's passing a river is a circumstance which frequently occurs in war. Independent of the preparations for that purpose, which principally concern the disposition and movement of troops, there is likewise much work for an engineer; and as far as relates to that, I will explain the method of fortifying a river, in order to oppose an enemy's passage.

First of all, that the enemy may not cross any where unobserved.

1. The troops must spread along the river, throughout the whole extent where it may be expected an enemy will attempt to pass; and at intervals of about a mile, posts should be established, consisting of about two battalions, and some cavalry. These small posts are to observe all the motions of the enemy on the opposite side of the river; for which purpose patrols should be constantly sent out, especially by night. The main body of the army encamps behind these corps, in such a manner that it may be ready to afford them assistance every where.
2. Each of these posts must be intrenched; and

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the engineer ought to be particularly attentive, that the fire for the defence of the river may be as horizontal as possible.

The communication between these posts, and from each of them to the main army, should be secure and commodious.

3. If the river is broad, people may be sent by night in small vessels to the opposite side, more effectually to discover the designs and movements of the enemy.

4. Should there be islands in the river, which the enemy might make use of against us, they must be occupied, and fortified in the best manner.

§ 188.

When the river contains convenient fords, we should endeavour to destroy them. For this purpose entire trees may be cut down, and thrown into them: harrows may be fixed with their points upwards; a number of sharp stakes may be driven, &c. Any obstacles of this kind may be employed, and a work should be erected near them, to protect them by means of a fire of musketry; otherwise the enemy would have no particular difficulty in removing them, and clearing the ford.

If there are bridges across the river, they must either be broken down, or, as it may probably be desirable to preserve them, in order to make use of them as circumstances require, they may be covered

covered by strong tetes-de-pont, erected on the opposite side : or a work may be constructed on our side of the river, to enfilade the whole length of the bridge. (Pl. 12, fig. 5.)

§ 189.

When the enemy intends to cross the river, he will naturally make choice of a situation where it forms a bend towards him, (Pl. 12, fig. 6.) and where the banks on his side are higher than those on our side. By this means he not only commands the whole of the lower ground on our side, and can fire upon it with advantage, but also when our troops advance for the defence, he can take them in flank : and, moreover, the first troops which he sends over may form with their flanks secured by the river on both sides.

To deprive the enemy of this advantage, the chord, *ab*, of the curve formed by the stream, should be fortified with great attention. By this means, when he has even established his bridge, and some of his troops have actually passed over, they cannot advance further : so that he will derive no benefit from having effected his passage, until he has made himself master of the intrenchment in his front ; and this point will not be easily accomplished, if due arrangements have been made on the defensive side.

§ 190.

METHOD OF FORTIFYING A SEA COAST.

The defence of a sea coast is frequently of the greatest importance, and I will therefore briefly explain the measures an engineer may adopt to prevent the landing of an enemy's troops.

If a coast is several miles in length, and of such a nature that an enemy may land conveniently in every part of it, it must always be an undertaking of extreme difficulty for an army to prevent his gaining his object; and the very best intrenchments which may be formed in certain places for that purpose, can rarely be of any utility. It is true, measures may be taken to gain early information if an enemy's fleet makes towards any particular part of the coast, and if there are any indications of his disembarking troops: but if upon such intelligence the army should be allured to that spot, and make all possible preparations, and establish good works, the enemy's fleet may suddenly sail, and with a favourable wind arrive in a very short time at a part so far distant, that the army might not be able to reach it for several days. The enemy's troops would consequently have disembarked and intrenched themselves, before our army could approach them.

§ 191. But

§ 191,

But if the length of a coast is not very considerable, and if it is of such a nature that an enemy can only land in certain parts, he may be kept off with much less difficulty. In that case very important advantages may be derived from good intrenchments, and other preparations, such as were shewn with regard to the defence of a river. (§ 187—188.)

In those places in particular, where an enemy can conveniently land, strong batteries should be erected, and well furnished with heavy artillery. By this means the ships of war would be obliged to remain at a considerable distance from the shore.

In this case, there should be troops every where at hand to attack those who land first; and endeavour to throw them into confusion, before they can intrench themselves, or receive reinforcements. The detachments for this purpose ought to be perfectly covered from the fire of the fleet, either by the natural situation, or by breastworks; otherwise they would be sacrificed without necessity, and before they could be of any service.

The further arrangements for the defence of a sea coast, belong more properly to that part of military science which teaches the movements and disposition of troops.

§. 192. METHOD

§ 192.

METHOD OF FORTIFYING SINGLE HOUSES.

I will now consider the fortification of a single house. This is indeed a case which rarely happens at present; for since the use of artillery has become so universal, that a detachment of a hundred men seldom marches without guns, it is almost useless to fortify a single building, as it must soon be battered down to the ground. Nevertheless, situations may occur where the defence of such a post is both useful and important; for which reason I will explain the preparations proper for that purpose.

§ 193.

MANNER OF PREVENTING THE ENEMY'S ACCESS.

When a house, a church, a farm yard, or any considerable place of the kind, is to be put into a good state of defence, the first object is to endeavour as much as possible to prevent the enemy's access.

If for example, the post is the wall of a church-yard, which lies in the midst of a village; all the roads and avenues leading to it must be blocked up as far as the range of musket shot. For this purpose carriages or harrows may be fixed as before described; deep ditches, in which chevaux-de-frise, crows-feet, or palisades are placed, may be formed across the roads, &c.

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All the houses in the neighbourhood ought next to be examined; and such as might be detrimental to us, should be pulled down: those which are made of wood, should be laid open, that the enemy may not approach under cover, or fire in security upon us from the buildings.

§ 194.

METHOD OF BLOCKING UP THE ENTRANCES.

The entrances and gates leading to the post, must be well guarded and blocked up. If we have no occasion to pass and repass the gate, the enemy's entry may be prevented by means of strong beams fixed on the inside, if the gate opens inwardly; but if it opens outwardly, these beams must be firmly buried in the ground in front.

In both cases a quantity of earth or dung should be heaped up against the gate, and the enemy would then find great difficulty in effecting a passage, even though he should employ considerable force.

But if we wish to preserve a free passage, a fleche or any other work may be formed, either before or behind the gate. In this work a small opening is left, which must likewise be properly covered. In Pl. 13, the first figure represents some works of this nature. They may be constructed of earth in the usual manner; and if the breastwork is but sufficiently strong, and provided with palisades, fraises,

fraises, or chevaux-de-frise, the gate may be looked upon as properly covered.

Most engineers however recommend for this purpose, simply to fix palisades close together, according to the figure of the work; and openings must then be cut in the palisades, that the soldiers may fire through them. A work of this kind is called **A TAMBOUR**, and is shewn in the second figure. A small pointed ditch may likewise be dug in front of the tambour; and the earth excavated from it thrown forwards in form of a glacis. By this means the tambour is better covered against the enemy's musketry; and is less exposed to be injured by any burning materials he may throw, as they must fall into the ditch. See fig. 3.

§ 195.

REMARKS CONCERNING THE WALL.

Certain alterations must likewise be made with regard to the wall, in order to obtain a better defence.

1. A banquette is formed behind it, and if necessary, the upper part of the wall must be knocked down, sufficiently to admit of the soldiers firing over it. If the wall is too weak, a ditch is formed in its front; and the earth thus obtained, is thrown up against the wall (Pl. 13, fig. 4.): but if there is any danger of being disturbed by the enemy in executing this, the ditch may be made within the wall

wall, and the earth thrown over it. (fig. 5.) The banquette is composed partly of the stones or brick knocked off the wall, and partly of earth.

2. If the wall is very high, instead of breaking down the upper part, openings may be made in it (fig. 6.); through which the soldiers place their muskets, in order to fire on the enemy. As many of these openings, which are termed LOOP HOLES, should be formed, as the wall will allow without being too much weakened. The height of a loop hole is about two feet on the inside, and three or even four feet on the outside. The top is horizontal; but the bottom should have a slope downwards, that the enemy may the better be fired upon at the foot of the wall. The breadth on the outside is five or six inches, but on the inside 12 or 15 inches, that the soldier may be enabled to fire in various directions.

3. In walls which are very high, two rows of loop holes may be made, one above the other; and in order that the fire of the garrison may spread the better over the whole space in front of the wall, the loop holes should not be directly over one another, but so disposed that those of one row may be in the intervals of those of the other.

In this case, the under row of loop holes may be very low, by which means the foot of the wall receives a good defence; and a ditch must be dug behind it, of such a depth that the soldiers standing in it can fire conveniently through them. There is no banquette here, but a scaffold of tim-

ber is erected for the men who are to fire through the upper row of loop holes. See fig. 7.

§ 196.

4. In a wall, as well as in a redoubt, the angles are the weakest parts, as they have no defence. Therefore, that the enemy may not derive any advantage from this defect, loop holes should be formed immediately in the angles; or which is still better, we should endeavour every where to obtain a flank defence. There may probably be certain projections in the wall, which will answer that purpose.

This is the case, for example with a church in form of a cross, and nothing is then necessary but to pierce the loop holes. But if the wall has no flank defence of itself, a tambour or fleche should be constructed in front of each side; or tambours may be erected in the manner of bastions, at the angles. All these works must have an immediate communication with the space behind the wall; for which purpose openings are made through the wall, and covered in the rear by tambours. See fig. 8.

5. If we wish to protect the soldiers, especially those in the tambours, from the enemy's shells or grenades, it may be done by forming a kind of roof over these works. The nature and construction of such a roof will be clearly seen in the ninth figure. Beams and boards are first laid over it,
and

and earth or dung is heaped upon them, by which means the troops are effectually sheltered.

6. Lastly, if the post to be defended is the wall of a house or church, the windows may serve instead of loop holes: but to prevent the enemy's killing our men at the windows, they should be closed up by planks, in which loop holes are cut. If the walls are not too thick, loop holes may also be pierced between the windows; and we should here likewise endeavour to procure a flank defence by means of tambours.

§ 197.

OF ARTILLERY IN POSTS OF THE ABOVE DESCRIPTION.

Artillery may be employed in posts of this nature, either by means of openings cut through the wall, or by firing over the wall in the manner of a barbette battery. The latter method is to be preferred when the wall has no roof, and is not too high: but on the contrary, in an enclosed and covered building, or where the wall is very high, loop holes should be cut for the guns. These loop holes are about a foot broad on the outside, and three feet on the inside, for the purpose of better defending the ground in front.

§ 198.

REMARK CONCERNING THE ROOF AND VARIOUS STORIES.

When the roof of a building to be defended is covered with thatch, or shingles, it should be taken down and removed; and wet dung laid upon the upper floor, to prevent the house being easily set on fire.

If the roof is covered with tiles, it need only be pierced through in certain places, to keep off the enemy, and prevent his scaling it by means of ladders; and for this purpose it is also proper to have a provision of stones on the upper floor, which may be thrown down upon the enemy, when he attempts to fix the ladders, or at any time that he is close under the wall.

If the building consists of several stories, it is adviseable to break through the floor of the upper stories in several places, and especially above the doors. By means of these openings the enemy may be fired upon, or otherwise opposed in his attempts to enter. Count Saxe had recourse to this contrivance in the inn where he defended himself against the confederates. As soon as any of the Polish troops entered the doors, they were killed, and the assailants were obliged to desist from that kind of attack.

§ 199.

RETREAT FROM ONE POST TO ANOTHER.

When there are several posts behind one another, by which means the garrison may gradually retire when obliged to abandon any of them, particular attention should be paid that the retreat may be conducted without confusion or danger. Suppose, for example, we are posted in a churchyard, and wish to reserve the church as the last place of defence; we ought to make such preparations that the troops may retire in security from the churchyard to the church. For this purpose, in front of the church door, a tambour is erected, leaving only a suitable opening close to the wall. The door remains open until all the soldiers are in the church, and is then shut, and blocked up in the strongest manner. Loop holes may likewise be cut in the door, more effectually to keep off the enemy.

§ 200.

METHOD OF FORTIFYING A SMALL TOWN.

I shall conclude this chapter with a brief explanation of the manner in which a small town may be advantageously fortified against the attack of an enemy.

1. When a town is surrounded by a wall with gates, according to the ancient mode, the first

first object is to block up the gates carefully. But if we wish to keep one gate open, a fleche or any other strong work should be thrown up in its front. Through this work a passage is made sufficiently broad for a gun: and this entrance is not only closed by chevaux-de-frise, but is likewise covered in the rear by a traverse. Moreover measures should be so concerted that this gate may likewise be blocked up as soon as the enemy advances to the attack.

2. Loop holes ought to be pierced every where in the wall surrounding the town; and the necessary scaffolds erected for the soldiers to stand upon. If there are any towers projecting from the wall, they serve to furnish a flank defence for all parts, and especially in front of the gates. If the town is likewise encompassed by a large ditch, the bridges must be pulled down, or a strong work erected in front of each bridge.

3. Traverses are formed in the streets leading to the gates, by which means, when the enemy endeavours to enter, he will be exposed to a double and triple fire.

4. A place must be fixed upon within the town, to which the garrison may retire when the enemy has entered the town. It may be either a single building, or a certain part of the town; and should be fortified with the greatest

greatest attention, according to the foregoing rules.

5. Every thing within musket shot of the walls, which might prove of any advantage to the enemy, should be removed; and on the contrary all possible obstacles should be presented to render his approach extremely dangerous and difficult.

FIRST PRINCIPLES
OF
FIELD-FORTIFICATION.

PART II.
OF THE ATTACK AND DEFENCE OF
FIELD-WORKS.

CHAPTER I.

ATTACK AND DEFENCE OF SMALL FORTS.

§ 201.

ATTACK.

A SINGLE fort which has been put into an advantageous state of defence, and where no means have been spared to oppose the enemy's access, must render every attack upon it, however powerful, a circumstance of great difficulty, unless supported by artillery. But if we can bring even three or four guns against it, so as to batter the breastwork for a few hours; and particularly if with these we can unite the use of a howitzer, from which shells may be thrown into the fort, the work must certainly be knocked down; and the garrison being then exposed to our fire, would from

from necessity be reduced to surrender, or at least to abandon the post.

§ 202.

If the fort consists merely of earth-work, without having trous-de-loup, or any other obstacle in its front, it may generally be carried in the following manner.

The troops composing the detachment destined for the attack, which must always be much stronger than the garrison, march towards an angle of the fort, as this is commonly the weakest part.

They advance in the greatest haste to the ditch, and leap into it. Having there rested a short time, they must climb the breastwork, form into order, fire upon the garrison, and immediately leap down into the work. It would be better if the troops during their march to the attack, did not fire at all; as it only occasions delay, without being of any essential service. Nevertheless, as the soldier may probably imagine he derives great benefit from it, and as it may give him confidence, the troops in their advance, may fire towards the fort. They must however by no means remain still; as the garrison would thereby acquire much too great an advantage over them.

If before the assâult circumstances will allow us to fire upon the fort and garrison from our guns and howitzers, the enterprise will the more easily

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succeed;

succeed: and above all, if the assailants are but sufficiently bold and valiant to scorn the fire from the fort, which frequently is not so dangerous as we are apt to conceive, it may be expected that the garrison at the sight of this determined conduct, will the sooner cease defending itself, and either yield or retire.

§ 203.

I have observed in the foregoing paragraph that prior to the assault, it would be of service to cannonade the fort: there are cases however, in which this would be totally improper. For example, if we wish to surprise an enemy in his intrenchment, and that we are enabled to advance as far as the ditch undiscovered: it would here evidently be absurd to make use of our artillery, and thereby give him notice of our arrival. Again, suppose we are to attack a fort situated in front of a village, and that we know the greater part of the garrison is posted in that village; if we can approach within musket shot of the work without being perceived, this would be the most advantageous method of attacking it: for if we were first to fire upon the fort, it would afford the enemy time to throw himself into it.

§ 204. When

§ 204.

When our force is very superior, and the situation will allow it, a garrison may sometimes be compelled to surrender without our making any regular attack. I here suppose that the enemy within the fort, can defend himself no longer against a superior power, than whilst he has ways and means reserved of retreating, or of receiving reinforcements and succours. If then we can cut off his retreat, and dispose of our troops in such a manner that no relief can reach him, necessity fully justifies the garrison's giving up the fort. This method is infallible, and ought to be preferred to all others, as it is effected without the loss of a man, and requires no particular preparations.

§ 205.

DEFENCE OF FORTS.

With respect to the defence of a field-fort constructed upon good principles, and provided with a sufficient garrison; the officer entrusted with this charge ought first to examine the whole of the neighbouring country, and cause every thing to be removed which lies within musket-shot of the place, and might be favourable to the enemy in his attack. He must next adopt proper measures to prevent being surprised; and for this purpose, the

men should be constantly collected together; and if the enemy is very near, the whole should be under arms towards day-break. The centinels should receive injunctions to be extremely attentive to every noise during the night; and to report any occurrence that appears the least suspicious. Lastly, people should be sent out in all directions, to give immediate notice when they perceive any thing like a movement of the enemy.

As the defence of a field work against the attack of a superior enemy cannot be expected to last long, the officer should beforehand carefully examine the road by which he must retire; and project the whole order of retreat, to prevent the confusion which might otherwise ensue; and here he ought particularly to consider how near he may allow the enemy to advance, without subjecting the garrison to be cut off.

§ 206.

The actual defence is conducted in the following manner.

1. The officer arranges his men two deep around the whole circumference of the fort; retaining about a fifth part of the garrison for a reserve. The engineer who constructs a fort of this nature, must also keep this in view when he determines the dimensions of the work, in order that the circumference may not be too great. For this purpose

pose he must deduct the number of men allotted for the reserve from the whole garrison, and then lay out the work for the remainder.

2. Cannon may be fired as soon as the enemy is within reach; and when he has advanced within about 300 yards of the work, the guns should be loaded with grape shot. A few rounds of this nature brought to bear properly, would produce an astonishing effect, and must inevitably throw the enemy into disorder.

3. Small arms ought never to be used until the enemy is within 200 yards of the fort, and then a brisk and constant fire of musketry must be maintained.

4. Finally, should the enemy leap into the ditch, every endeavour must be exerted to prevent his mounting the breastwork; and here the garrison has undoubtedly the greatest superiority. The soldier striving to raise himself on the work, is not enabled to do much harm; whereas the garrison, provided it is but sufficiently collected, may give him such a reception with the bayonet, or the butt end of the musket, as must oblige him to draw back. And whilst he is in the ditch hand grenades may be thrown to his great annoyance. If however, he should at last scale the breastwork, and the garrison abandons it,

it, the reserve must be brought forwards ;
 which being still in good order, and not
 having hitherto sustained any loss, will
 very probably vanquish the weary and ex-
 hausted enemy, and drive him from the
 fort.

CHAPTER II.

ATTACK AND DEFENCE OF TETES-DE-PONT.

§ 207.

ATTACK.—FIRST CASE.

IN the attack of a tete-de-pont, the same circumstances frequently occur as were mentioned in the foregoing chapter concerning the attack of small forts in general. It is therefore needless to repeat them here, and I shall only consider some particular cases, and point out the mode of conducting an attack in such situations.

First, to prevent an enemy's passing a river, though he has completed a bridge over it; a fortunate and decisive stroke may frequently be effected, by attacking him whilst his army is in the act of crossing. The troops are then separated from one another by the river, and consequently if we attack those who have already passed, we have at all events to engage with only a part of his army. It must undoubtedly be expected that the enemy has already intrenched himself, to cover the bridge, and passage of his army, and that we have therefore to attack a tete-de-pont. In this case a direct assault should be made, and we must endeavour, whatever it may cost, to scale the work. There is every reason to expect such an attack

will succeed, as in all probability the intrenchment is not yet in the most perfect condition. It is moreover a sort of surprise, and experience teaches that when troops are taken suddenly and with violence, they seldom preserve sufficient composure, and are easily thrown into disorder.

§ 208.

SECOND CASE.

Again, if an enemy either wishes, or is obliged to retire across a river, by means of a bridge, we may render his retreat very difficult by making a powerful attack upon him as soon as a considerable part of his army has passed over the bridge: the remaining part must then apparently be easily beaten.

We must here suppose that the enemy, in order to cover his retreat, has thrown up both large and small intrenchments (§ 186.) constructed in the best manner; and it therefore appears that we have likewise to attack these works, which being very strong, may occasion great difficulty. However, I scarcely think in this case it can come to a regular attack of the intrenchment; for as the enemy's army was supposed at first on the outside of the works, and endeavouring by degrees to retire across the bridge; it follows that there is nothing to fear from the intrenchment until such time as his army is beaten and thrown into confusion: and in that situation

situation he will hardly retain any further thoughts of making a proper defence of the works.

If we were to wait until all the enemy's troops had retired, except those destined for the garrison of the intrenchment, the attack would become too dangerous. All that can then be done is to cannonade the enemy in the most vehement manner during his retreat; and if possible to direct the fire of our artillery particularly against the bridge: for should we succeed in battering it down, the troops who had not crossed the river must to a certainty be thrown into our power.

§ 209.

THIRD CASE.

A third case is, when we want to destroy, or deprive the enemy of a bridge which is of infinite importance to him. Suppose, for example, he has passed over a river, and left his magazine behind. He would undoubtedly be thrown into the greatest embarrassment by the loss of the bridge, and the disadvantage he would thereby sustain would amply recompense the difficulty of the enterprise.

As we suppose the bridge to be of great importance to the enemy, we must naturally expect that he has thrown up strong intrenchments to cover it; and has probably left not only a sufficient garrison for these works, but even a considerable part of the army for their protection. Consequently

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we may be unable to approach and destroy the bridge until we have first beaten this body of troops, or at least made ourselves masters of some strong forts. The manner of proceeding with an attack in such cases hath been already shewn; it is only necessary to remark that a great body of troops, and in particular a numerous artillery is requisite, to prevent the failure of the object proposed, which might prove of the greatest disadvantage.

§ 210.

DEFENCE.—FIRST CASE.

The three examples given above must likewise be taken into consideration with respect to the defence. When, as in the first case, an army is to cross a river, and there is reason to apprehend being attacked during the passage, it is always a circumstance of danger, and should be conducted with the greatest circumspection. Every thing here depends on whether those troops who first cross the bridge are enabled to throw up a tenable intrenchment before the enemy can attack them. A general should therefore know how to compare the time requisite for a sufficient number of troops to pass over the bridge, and intrench themselves on the other side, with that taken up by the enemy's army in its march towards us; and should endeavour by all possible means to avoid an attack. The method of erecting works by means of bags filled

filled with earth (§ 165.) might here be practised with great advantage; and it might frequently be useful to employ chevaux-de-frise.

§ 211.

SECOND CASE.

If according to the second case, an army is to retire across a river, and that it may be attacked during that time by an enemy following it; I suppose beforehand, that a large work is erected which encloses the small tetes-de-pont (§ 186.), and is constructed upon proper principles. The army forms before the intrenchment, with its front towards the enemy; and under a constant fire retires by degrees behind the work, and from thence across the bridge. When there no longer remain any troops on the outside of the intrenchment, we must prepare for the defence of these works, for which purpose they should be provided with proper garrisons, and sufficient artillery.

In order that the garrison of the large intrenchment may also retire over the river, strong batteries should be thrown up on the opposite side, so as to form a cross-fire in front of the work. The troops on the side of the work nearest the river then gradually withdraw through the small tetes-de-pont, and over the bridge: and finally, those who actually manned the front of the intrenchment hasten to the ditch of the small works, form according to the figure of the ditch, and front the enemy. They

then retire by files into the small works and cross the river.

The garrisons of the small têtes-de-pont ought also to be enabled to retreat in security, and for this purpose the fougasses which were formerly described, may be applied here, and placed within the large intrenchment. By this means the garrisons would undoubtedly gain sufficient time to cross the bridge.

Lastly, when all is safe, the bridge is taken up, or if it cannot be carried away, it should be completely burned or otherwise destroyed.

§ 212.

THIRD CASE.

In the third case, when the preservation of a bridge is of very great importance; nothing particular can be said concerning the defence of the tête-de-pont. If there is a body of troops left on purpose for its protection, they must endeavour to keep off the enemy, and beat him. The necessary manoeuvres to that effect do not belong here. If we are to defend ourselves in the works, all the rules given in §. 205—206 must be followed in the most cautious manner.

This is a situation where an officer must defend the post entrusted to him, to the last extremity: for as the welfare of the whole army depends thereon, nothing can excuse his abandoning the post, or yielding it to the enemy. However when he perceives

perceives any signs of an enemy's approach, he should give notice thereof to the corps nearest him, that relief may arrive as speedily as possible.

§ 213.

Every thing that has here been said concerning the attack and defence of tetes-de-pont, is with very trifling alterations applicable to works thrown up when troops are to land on a sea-coast, or to embark.

When troops have effected a landing, they must always expect to be speedily attacked, and ought therefore to endeavour to intrench themselves as quickly as possible. The rules laid down in § 207 and 210 should here be observed.

If troops are to embark, we must proceed according to the directions in § 208 and 211, and the advantage there gained from the batteries erected on the opposite side of the river, must in this case be procured from the fleet.

CHAPTER III.

ATTACK AND DEFENCE OF SINGLE BUILDINGS,

§ 214.

ATTACK OF A HOUSE, OR OF A COURT-YARD SUR-
ROUNDED BY A WALL.—WITHOUT CANNON.

IT is not easy without artillery to conquer a resolute and valiant garrison in a post of this nature, though it may appear but weak.

The following means may nevertheless be adopted for that purpose.

1. When the loop-holes in the wall are very low, a sufficient number of troops march directly up to the wall, and run their muskets through the loop-holes, by which they will probably drive the garrison from the wall. Upon this, the wall must be forced down, either by a kind of battering-ram, or in any other manner, and a passage thereby procured into the enemy's post.
2. If there is not any flank defence to the wall, or even loop-holes pierced at the angles, it may sometimes be there undermined with tolerable security, and thus destroyed.
3. Again, if the wall has no flank defence, and the loop-holes are so far asunder that ladders

adders may be fixed in the intervals, an escalade may be attempted.

4. Lastly, if the post is a single building, covered by a roof, and there are means of setting it on fire, this is the most certain way of compelling the garrison to surrender. However, if we have no mortars or howitzers; if the house is covered with pan-tiles, and very substantial; and particularly if the garrison takes proper precautions, it must always be very difficult to effect this. On the contrary, if the building is covered with wood, or thatch, which the enemy should have neglected to take down, it may easily be burned.

§ 215.

ATTACK WITH CANNON.

If we have artillery, and the wall is not very strong, the most certain method is to batter it until a regular breach is made, which must not be too small, that a considerable body of men may enter at once. This precaution is particularly necessary when we know that the enemy can retreat to another post, and will defend himself to the last extremity.

The tambours which are sometimes built in front of a wall, to give it a flank defence, may also be easily knocked down by cannon shot.

Lastly,

Lastly, if there should be any eminence in the vicinity of the post, we should take advantage of it, and from thence keep a brisk cannonade upon the garrison.

§ 216.

As it must at all times be expected that a garrison in a post of this description, may receive reinforcements, or even be entirely relieved; we ought to send out detachments in all directions during the attack, to prevent being surprised in the rear by a new enemy.

From the beginning, the necessary measures for our retreat should be considered, that we may not be cut off, even though the attack should fail.

§ 217.

DEFENCE.

With regard to the defence of a house or courtyard, I shall only quote a few rules, and entirely pass over every case similar to those already treated of.

1. When a garrison expects that the defence of such a post will last some days, it must have a sufficient supply of provisions, which should be preserved in the most secure part of the post, that the troops may not be compelled to surrender by hunger or thirst. This precaution may prove of essential advantage

advantage when the detachment of the enemy which arrives first is too weak for the conquest of the post, and must therefore wait for more troops. The garrison may indeed be blockaded by the first detachment, but need not be obliged to surrender whilst it has a sufficient quantity of provisions.

2. Upon the upper floor of the house, a great number of stones should be collected, which may be thrown down upon the enemy should he attempt to undermine the wall, to scale it by means of ladders, or to run his muskets into the loop-holes.

3. A still better method of opposing an escalade, is to prepare some large beams on the upper floor, which may be rolled down upon the enemy's troops whilst they are on the ladders.

4. A great supply of water should be in readiness in the house, and on the upper floor, that should it any where take fire, it may be quickly extinguished; and the post should therefore be provided with the necessary engines for that purpose.

5. If time will not allow the garrison to block up the door, and cut loop-holes in it; as soon as there are signs of the enemy's being at work there, an incessant fire of musketry should be directed towards the door, and if it is made of soft wood, the balls will pierce it. Should the enemy succeed in bursting

it open, he must be vigorously opposed with the bayonet.

§ 218.

RETREAT TO THE INNER POST.

If the first place to be defended is an open courtyard, and the garrison can retire to any particular building as a reserve, when it can no longer maintain the court, the retreat is conducted in the following order.

1. As soon as it is perceived that the enemy will make a breach in the wall, the troops who are most remote from the side of attack, begin to withdraw into the building, and only those at the side of the breach remain in their station.

2. When the breach is become practicable, those men also run in the greatest haste towards the tambour which covers the door, and form along it, fronting the enemy. They then by degrees, and under a constant fire, retire by files behind the tambour. Even though the enemy may enter the breach with great force and rapidity, there need be no apprehensions of his following up the troops in their retreat, so as to enter the building with them. Not only the fire of the retiring troops, but that of the garrison of the tambour and building would detain him from such an immediate pursuit.

3. Lastly,

3. Lastly, when the tambour can no longer be defended with any certainty, the whole garrison retreats as quickly as possible into the building: and as soon as the last man has entered, the door is shut, and blocked up, for which purpose every thing should be ready beforehand.

§ 219.

This last post may frequently be maintained a long time in expectation of relief, or an opportunity of making an escape: but if at length there is no appearance of assistance, and it is impossible to make any longer defence, the officer must decide whether he ought to make any further resistance, or surrender the post to the enemy. He should adopt the latter conduct if an obstinate defence could prove of no more use; for in this case it would be only fool-hardiness to sacrifice himself and his men without necessity. On the contrary, if the welfare of the whole army depends on our post, or if in conformity to orders we are to defend ourselves to a man, it is our duty in this and similar cases to hold out to the last extremity, and to risk all consequences rather than capitulate with the enemy.

§ 220.

PRECAUTION RESPECTING AMMUNITION.

It is easy to perceive that throughout this defence, a great quantity of gunpowder and ammunition must be expended; and therefore that the garrison may not be reduced to the necessity of surrendering for want of these articles, care should be taken beforehand to provide a sufficient supply thereof. It should be kept in the most secure part of the intrenchment, and all possible precautions taken to preserve it from fire. It should likewise be distributed very sparingly, and in the actual defence, particular attention should be paid that the soldiers do not fire until the enemy is completely within reach.

It is not always possible to foresay the quantity of ammunition that will be used, as it cannot be known how many attacks the enemy may make, and how powerful those attacks may be; however, it is always better to have rather too much than too little. If we allow 200 rounds for each soldier, and 50 rounds for each gun, it will in most cases be sufficient.

CHAPTER IV.

ATTACK AND DEFENCE OF AN INTRENCHED VILLAGE.

§ 221.

ATTACK.—FIRST CASE.

It frequently happens in war, that a village is to be attacked, and the proceedings for this purpose must be variously regulated, according to circumstances.

First, if an enemy's corps on its march finds itself incommoded by our cavalry, it may probably throw itself into a village for security. In this case our cavalry should blockade the village and send for a re-inforcement of infantry, without which nothing further could be executed. During this time it must be expected that the enemy will intrench himself in the village to resist the attack of our infantry; but as time and means must apparently be wanting, he will not be able to complete any extensive and strong works. However he will have blocked up the avenues to the village, and fortified some particular building in the best manner, as a place to which he can retire at last, and make a good capitulation. The method of attacking such a post is known from the foregoing chapter; but as our troops are here enabled to

make preparations for the attack, the best way is to take some howitzers, and thereby set fire to the whole village. The enemy must then either yield or endeavour to fight his way through, and we must certainly be sufficiently strong to prevent his succeeding in the latter attempt.

§ 222.

SECOND CASE.

Again, when in front of an enemy's army there lies a village which flanks his position and which he has occupied; if we are determined to engage the enemy, this village must first be attacked and carried; but as the preservation of it is of great importance to him, we must here expect strong works and an obstinate defence. The attack must therefore always be very doubtful, but if it must take place, the following circumstances should be observed.

1. We may first endeavour to set the whole village on fire. It is true we may not entirely drive the enemy away, nevertheless it will be very prejudicial to him; and if we are so fortunate as to force the troops from the intrenchment, their retreat through the village in flames must be extremely difficult; and at all events the enemy will not be able to throw himself into the houses, and fire upon us.

2. Prior

2. Prior to the assault, a violent cannonade from heavy guns, should be kept up against the works of the village; thereby endeavouring to disconcert the troops, to ruin the works, to render his artillery useless, and to remove the several obstacles which may be in our way, and might afterwards obstruct our advance.

3. A village lying in front of an army is fortified in three places, namely in front and on both sides, but the actual attack should be carried on against the front only; for if we were to direct our attack against either of the sides, we should not only be opposed by the garrison of the village, but should be taken in flank and perhaps in reverse by the main army. On the contrary, if the village lies on one of the flanks of the army, it is adviseable to undertake an attack on more sides than one at the same time; for by this means the enemy cannot apply his whole force to any one side, and may therefore be more easily driven away.

§ 223

4. When the actual attack is to take place, the strength of the party must be regulated so as to observe a proper proportion to the garrison. Four, six, or eight battalions are in most cases sufficient, and they should at all

all times be accompanied by cavalry for their support. They may be formed in two divisions, or more if an obstinate defence is expected, and march with a quick pace directly towards the village. When they are arrived within musket shot of the works, the first division begins to fire.

Should it not succeed in driving the enemy from the breastwork, when it has expended its ammunition; or should it be thrown into disorder, it retires through the second division, which advances, and begins to fire. Should this division also be unable to make any impression on the enemy, it must in like manner be relieved by fresh troops, and the attack must proceed thus until at last we perceive the enemy begins to give way. We should then make a powerful effort to enter the village, for which purpose the pioneers and carpenters must remove all obstacles, and make large openings into the works.

5. The troops must be very cautious not to be thrown into confusion, and follow the enemy too warmly; for as it is very probable he will endeavour to recover the village, they should form in order of battle, and consider in what manner they may receive him should he return with succours. If the village should be retaken, another attack

tack must be made, with fresh troops who can renew the fight.

6. The cavalry who accompanied the party for the assault must cover the infantry, if it is obliged to retreat; or if the garrison should make a sortie from the village, and in the heat of action advance too far, the cavalry should make a desperate charge upon them.

§ 224.

THIRD CASE.

Lastly, an attack of a village may occur, when we wish to disturb an enemy's army lying in cantonments. The conquest of such a post in the chain of an enemy's quarters is frequently connected with the most important advantages, but it is not easily accomplished, and is generally impossible unless by surprise. The following remarks however are to be observed.

1. We should endeavour to conceal our designs from the enemy, by all possible means.

We should seize all plausible pretexts to let our troops approach the enemy's quarters; and the last march should be conducted with the greatest silence and circumspection.

2. As it must be expected that the adjoining quarters will come to the assistance of the part attacked, we should previously examine how soon the enemy's relief can

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come,

come, and post a body of troops to prevent his approaching the village during the attack. Or a false attack may be made upon the neighbouring quarters, to divert the enemy's attention, and prevent his sending assistance to the village where the actual attack is carried on.

§1. As soon as the assailants arrive at the village, they must use their utmost endeavours to gain speedy possession of it. If they can enter before the enemy is aware of it, it would be best; but if he is prepared, the attack must be conducted according to the rules in § 222, 223.

DEFENCE OF A VILLAGE.

With respect to the defence of an intrenched village, I shall make a few remarks, and refer to the foregoing chapter, for the necessary preparations.

§1. An officer quartered in a village must be extremely alert, and use his utmost endeavours by means of spies and patroles, to gain a knowledge of every movement of the enemy.

§2. When he gets any such intelligence, he must report it to the general, and concert with the corps destined for his support, certain

certain signals which he is to give when he requires their assistance.

3. If danger is very near, his garrison must remain under arms the whole night, and particularly towards day-break, that the enemy may not take him unprepared.

4. Lastly, when the enemy actually arrives, he must defend himself as long as possible: but if he is obliged to abandon the intrenchment, he must retire to the place of reserve, and wait for relief.

WHEN an intrenched camp is to be attacked, we should first of all endeavour to acquire a perfect knowledge of its nature and condition. For this

purpose, I. We must advance as near as possible to the

enemy's intrenchment and examine it thoroughly. In order that the persons thus

sent to reconnoitre may not be obstructed, or taken by the light troops who may pro-

bably have occupied the rocks and villages for a considerable distance about the post,

they should be accompanied by a covering party, the strength of which must depend

on circumstances. By this actual inspection, we not only

obtain information relative to the situation of the enemy's works, and the flank defence

which the lines of his intrenchment receive from one another; but a better knowledge

of the ground is gained which enables

CHAPTER

CHAPTER V.

ATTACK OF A FORTIFIED CAMP.

§ 226.

MANNER OF GAINING A KNOWLEDGE OF THE
ENEMY'S CAMP.

WHEN an intrenched camp is to be attacked, we should first of all endeavour to acquire a perfect knowledge of its nature and condition. For this purpose,

1. We must advance as near as possible to the enemy's intrenchment and examine it thoroughly. In order that the persons thus sent to reconnoitre may not be obstructed, or taken by the light troops who may probably have occupied the roads and villages for a considerable distance about the post, they should be accompanied by a covering party, the strength of which must depend on circumstances.

By this actual inspection, we not only obtain information relative to the situation of the enemy's works, and the flank defence which the lines of his intrenchment receive from one another; but a perfect knowledge of the ground is gained; by which we are enabled

enabled to judge how far it may be advantageous or prejudicial to us in our attack.

2. We may procure from prisoners and deserters a more minute account of the actual condition of the breastwork, and of the whole intrenchment. For example, we may ascertain nearly the breadth and depth of the ditch—whether there is an advanced ditch in front of the work—and the general measures which the enemy may have made use of to secure his intrenchment against an attack.

We ought not however to give confidence to the information of any one soldier, as he might easily deceive us, either by design, or through ignorance; but should collect the reports of several people. If they agree, and we are convinced they cannot have been concerted, we may safely rely on them.

3. Trusty and discreet spies may be sent into the enemy's camp with instructions concerning the particular points to which they should attend, and the information they should collect.

§ 227.

PROJECT OF ATTACK.

Having obtained a perfect knowledge of the enemy's intrenchment, and the ground about it, the project for the actual attack must be formed.

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There may possibly be some road leading round about the post, by which we might enter it, without making ourselves masters of the works; or at all events, if it is found from observation that it is not every where equally strong, we can direct our principal attack against the weakest part. This however must not here be estimated alone by the nature of the works, as for example, because the ditch is not so broad and deep, or the flank defence not so strong in one place as another, &c.; but the weakness of any particular part of the intrenchment frequently depends entirely upon the ground. For example, if in front of any part of the camp there is an eminence from which we could fire upon the enemy in the camp, and behind the breast-work; this is always a weak situation, and of great advantage to the assailants.

§ 228.

NUMBER OF ATTACKS.

We must also determine beforehand, the number of attacks, both real and sham, which are to be made upon the enemy's intrenchment. The more attacks we can make the better, as the enemy's army thereby becomes the more divided. According to the opinion of many engineers, the real attacks should not be very far asunder, that they may be able the more readily to assist one another: nevertheless there are cases where a deviation

tion from this rule would not be attended with any disadvantage, but even be of service.

§ 229.

TIME OF ATTACK.

Most people skilled in the art of war conceive the best time of attacking a fortified camp, to be about an hour or two before day-break. The enemy cannot then distinguish between the real and false attacks, or discover our order of battle; and our soldiers have less to fear from his fire: whereas, since the attack is made only a short time before day-break, we are enabled by the time we have scaled the work, to see every thing, and pursue the enemy.

These reasons are certainly well imagined; nevertheless experience shews that by night, an army is very liable to be thrown into disorder; and if it marches in several columns, one of them may easily mistake its way, by which the whole project of attack may probably be essentially altered.

Again, it must be considered that all soldiers are not possessed of true courage, and may therefore not conduct themselves with proper valour and intrepidity in the night, when they are not observed. Such as are timid may possibly hide themselves, or be backward in the advance; and those who are bold merely from pride or ambition will undoubtedly endeavour to spare themselves, as their gallant conduct must pass unnoticed. A general ought

ought therefore to consider maturely, before he resolves upon a night attack. If the intention is to surprise the enemy, the night is certainly the best time.

§ 230.

ORDER OF BATTLE FOR THE ATTACK.

When we are to attack the enemy in a fortified camp by day, the army must be formed in a long extended line towards the intrenchment, endeavouring as much as possible, to conceal that part of our force, which is to make the most powerful attack. By this means the enemy is obliged to man every part of his lines equally strong, and cannot increase the defence of the place we attack, or draw his reserve nearer to it. It is not easy to conceal the actual attack; however any heights, hollows, woods, villages, &c. may be favourable for this purpose.

With respect to the disposition for the attack, the infantry are placed in the first division, and the cavalry in the second, and on the flanks. Against the principal side of attack, three or four divisions of infantry are formed behind one another, and afterwards compose the storming party. Lastly a corps of reserve should be posted at hand, to act where the greatest danger is expected.

§ 231. CAN-

CANNONADE BEFORE THE ASSAULT.

If the attack is to be executed by day, a heavy cannonade should be kept up for some hours upon the intrenchment and garrison, which will perhaps entirely drive the enemy from the works. At least many men must thereby be displaced, and several guns rendered unserviceable; and if we can batter down the breastwork, the passage over the ditch, and mounting the work, will become much easier.

For this purpose we should endeavour to find out the most advantageous situations for our artillery. If there are heights in the neighbourhood; from which we might conveniently overlook the camp, and fire into it, strong batteries should be erected upon them.

ACTUAL ASSAULT.

As soon as the good effect of our cannonade is perceived, the columns destined for the attack march directly up to the intrenchment. Each column usually consists of three or four battalions, formed three deep.

If necessary, 200 or 300 men with fascines march in front of each column, to fill up the ditch; and the front rank of the first division may also

carry fascines. Each column should be followed by about 100 pioneers, with spades and shovels, to pull down the breastwork as soon as it is scaled: and about 20 carpenters should also be in readiness to remove any chevaux-de-frise, or other obstacles placed in the entrances. Lastly, at some distance, a body of cavalry follows for the support of the infantry, or to pursue the enemy, as occasion may require.

When the front of the column arrives within musket shot of the enemy, it begins to fire. If it is thrown into confusion, or has expended its ammunition, it retires, and the following battalions advance and fire in the same manner.

The whole assault proceeds thus until the enemy abandons his works, and we can enter; or that the attacking column is obliged to retire.

§ 233.

This mode of attack has been censured by several people, and particularly by Count Saxe and Folard, who totally disapprove of the storming party's firing during its advance; from a notion that it retards the movement of the column, without being of any essential service, and affords the soldier a plausible pretext to stand still, and perhaps even to retire. I will in some measure admit this, but cannot consider the firing either as useless or prejudicial. It engages the soldier's attention, and prevents his reflecting on the danger he is in, or

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perceiving the number about him killed and wounded by the enemy's fire: neither can he observe their cries and groans, which might otherwise make an injurious impression on him. It is also probable that the fire of the enemy would have much more effect, if he was left quite quiet and had nothing to fear, than when he is likewise exposed to our fire. Moreover, experience shews that even the greatest generals have never been able, either by the strongest representations, or the most strict commands, to prevent soldiers firing in an attack. They always conceive that the enemy would thereby gain too much advantage over them, and therefore begin to fire as soon as they think they can hit him. From all these considerations, I am of opinion that it is adviseable to allow the troops to fire during their march, only taking care that it does not retard the attack.

§ 234.

Folard further objects to the troops for the attack being formed in so few ranks. He recommends that a battalion should be formed in 25 or 30 ranks, from a conception that the attack of such a solid body which he probably terms a column, must be executed with more rapidity and effect. A column of this nature would undoubtedly make a more impressive attack than a battalion of three ranks: but as the effect of grape shot upon such a body of men must be terrible, it would not be proper to form them into column until they arrived at the

ditch of the intrenchment; and it is very probable that in that situation, both officers and soldiers would neglect the manœuvre.

It is much more likely that they would use all their endeavours to cross the ditch, and mount the work as fast as possible.

§ 235.

MEASURES TO BE PURSUED AFTER THE ATTACK.

If the assailants are so fortunate as to drive the enemy from the breastwork, and to mount it, they must not in disorder leap down into the work, to pursue the enemy; for as he has apparently fresh troops in reserve, they would take advantage of our confusion, and attack us; and perhaps speedily repulse us. Our infantry should therefore remain upon the summit of the breastwork, form into order of battle, and wait there until the pioneers have made a sufficient opening for our cavalry to march through. As soon as the cavalry have entered, and the whole army is arrived, the troops advance in perfect order from the breastwork, and make a new attack upon the remainder of the enemy.

If the enemy should have left any guns behind the work, they should be turned about, and fired upon him in his flight. The further regulations for the pursuit of the enemy, or for a retreat, in case the attack should not succeed, do not come under the subject of this treatise.

ATTACK OF REDOUBTS.

I have hitherto considered particularly the attack of a connected work, but must likewise take some notice of those cases where the intrenchment consists of detached redoubts. The principle of the entire disposition remains the same. Before the assault a warm cannonade is directed against the redoubts and the troops behind them, and as the works are enclosed, a great number of shells should be thrown into them from howitzers. The several attacks against the different redoubts should be all carried on at the same time, that the attention of the garrison of each work may be taken up with its own defence, and thereby prevented giving a flank fire to any other redoubt adjacent to it. A separate column marches against every redoubt, and should consist of from two to four battalions, according to circumstances.

The whole army should follow these columns, to be ready to support them with fresh troops, in case the enemy should make a sortie. If the attack of the redoubts succeeds, they must be manned, and our troops march through the intervals to attack the enemy's army.

The attack of such works, covered by a whole army, must always be very doubtful, especially if the enemy is conscious of his advantage, and determined to defend himself to the last extremity.

CHAPTER VI.

DEFENCE OF A FORTIFIED CAMP.

§ 237.

DISTRIBUTION OF THE TROOPS.

WHEN an army in a fortified camp is to defend itself against the attack of an enemy, the first point to be considered is the mode of dividing and posting the troops behind the intrenchment.

1. The works must be manned throughout with infantry, formed at least two deep. If they can be placed three deep, though the third rank may not be able to fire with the other two ranks, it would nevertheless serve to replace any casualties without loss of time.

As soon as the enemy is within reach, the garrison should keep a constant fire upon him, and should he afterwards mount the breastwork, it must strive to repulse him by means of the bayonet. For the latter purpose, it might probably be advantageous to provide the men in the second rank, and all the non-commissioned officers, with long pikes.

2. The remainder of the infantry, which ought to be as strong as the afore-mentioned garrison, remains about 80 or 100 yards behind the breastwork ; and if it is not sufficiently

numerous

numerous to occupy the whole line, large intervals are left between the battalions.

Each brigade knows which part of the intrenchment it is intended it shall support, and in like manner the officers commanding the several parts of the lines, know to which brigade they should apply, if they require assistance. This reserve of infantry should likewise advance as soon as the enemy endeavours to enter the works, and make all possible exertions to drive him back.

In order that these troops, in case of an alarm, may be easily enabled to march to the proper places, the officers should make themselves thoroughly acquainted with the whole camp, and particularly with the road leading to the post assigned them, so that they may be able to find it even by night. It would therefore not be amiss, if the general was sometimes to try whether all the battalions repaired to their respective stations speedily, and without confusion.

3. The cavalry are distributed behind the infantry in like manner, to be every where at hand in case their assistance should be required. It was usual formerly to throw up works called EPAULEMENTS, to cover the cavalry; and it might at all times be of service to make use of such covering. At all events they should not be neglected if there are heights in the environs of the intrench-

intrenchment, from which the enemy could fire commodiously into the interior space of the works.

The Chevalier Clairac approves much of these epaulements, and recommends that the counterscarp of the ditches in front of them should be raised about two feet above the ground, and that infantry should be placed within the ditch, and fire over the counterscarp by means of a banquette.

§ 238.

It is evident that an intrenchment garrisoned in this manner, if it has an extensive front, requires a great army for its defence; and therefore when small armies undertake to defend works which are much larger than they can man, it is no wonder that they are so soon carried. Without troops the best and largest works are of no avail, and can certainly never keep off an enemy.

A general when he wishes to fortify a camp, should previously consider whether his army is sufficiently strong to garrison the intended lines; and if it appears that in order to preserve as great a front as the enemy, his line must be too much extended, he should rather contract it, and only occupy a smaller spot, that his defence may be the stronger; and if he only covers his flanks judiciously, his being out-flanked by the enemy is of no importance.

§ 239. MEANS

§ 239.

MEANS OF CONCEALING OUR SITUATION FROM THE ENEMY.

It is proper to conceal the condition of our works as much as possible from the enemy; for the more ignorant he is upon that head, the more uncertain his dispositions for the attack must be; and therefore to prevent his generals and engineers approaching to examine our works, a great number of light troops should make continual incursions every where in front of the intrenchment, and take post in the villages in the neighbourhood. They all retire into the lines if the enemy advances in force, but until that takes place, they prevent officers coming too near.

As the enemy will most likely send spies to gain information concerning our camp, and intrenchment, we should endeavour to discover them, or at least to be very circumspect before them: and we ought as much as possible to conceal the true condition of our works even from our own people, that the enemy may not gain sufficient knowledge of our situation, from deserters or prisoners.

§ 240.

MEANS OF PREVENTING A SURPRISE BY NIGHT.

Since there is nothing so much to be feared as
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being surprised in a camp by night, the following precautions should be observed.

1. When the danger is very great, the army must remain under arms at their posts, during the whole night; and it is particularly necessary to be constantly on the watch towards day-break.

2. Strong patrols should be sent out during the night, to observe all the motions of the enemy's army. If these patrols are zealous and alert, it is scarcely possible for the enemy to approach without being discovered.

3. Lastly, through the help of able spies we may learn when the enemy proposes to attack us; and can prepare accordingly.

§ 241. If the enemy actually advances to attack our camp by night, we should endeavour to light the whole country in front of the camp. By this means we are not only enabled the better to direct our fire against him, but can likewise view his entire disposition; and may probably discover which part of our intrenchment he particularly designs to attack. For this purpose, as soon as he approaches our lines, a great number of light-balls should be thrown towards him, from our mortars: or as Vauban recommends, at distances of about 200 yards from one another, piles of wood may be set up beforehand, about 30 yards from the ditch.

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These may be all lighted at the same time, when the enemy is sufficiently near; and that they may speedily take fire, some straw and small brushwood should be tied up with each pile. A small roof of boards should likewise be made to cover them, and prevent the straw getting wet.

§ 242.

KNOWLEDGE OF THE ENEMY'S DESIGNS.

It is always advantageous to find out as soon as possible which part of our works the enemy designs to attack; but this is particularly necessary, if we have not sufficient troops to furnish a proper garrison throughout. We ought to observe narrowly all the proceedings of the enemy, in order to draw conclusions as to his designs. This is however always doubtful, as he may easily deceive us by false movements, and therefore it must remain at all times a very difficult and dangerous undertaking, to defend extensive intrenchments with too few troops.

Sometimes, from the nature and situation of our post, and of the country about it, we may know beforehand which part the enemy will attack; and this is of great advantage, as we can then direct all our attention to that part, and strengthen it in such a manner that the enemy must find insurmountable difficulties.

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§ 243.

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§ 243.

CANNONADE.

It has already been mentioned that it would be of essential advantage to the enemy, if before the assault he could bring his artillery to bear upon our works, so as to injure them materially: we must therefore use our utmost endeavours to silence his batteries, and render his guns unserviceable. For this purpose a great number of heavy guns is requisite, and we should carefully strive to cover the artillery-men during the cannonade.

When the enemy's army advances towards the intrenchment, the guns should at first be loaded with round shot; as he draws nearer a heavy fire of grape shot should be kept up; and when he is within reach of musket shot, the infantry likewise commence firing.

§ 244.

DEFENCE, WHEN THE ENEMY IS IN THE
DITCH.

If proper measures have been taken to obstruct the enemy's approach to our intrenchment, his advance must have been attended with extreme disadvantage; but when he is actually in the ditch he is no longer exposed to the fire of the soldiers directly in his front; however in this situation

tion he may be greatly incommoded by hand grenades ; and if our works are constructed according to the preceding rules, he will have to sustain a very powerful flank-fire. If there is only one gun in each flank, it would when loaded with grape shot, produce an astonishing effect on the enemy.

If however the enemy should cross the ditch and endeavour to mount the breastwork, the garrison is drawn up behind it, with loaded arms, and fixed bayonets, ready to give him a warm reception.

§ 245.

DEFENCE, WHEN THE ENEMY HAS CARRIED
THE WORKS.

Should the enemy, notwithstanding all the obstacles hitherto mentioned, succeed in mounting the breastwork, and drive our garrison from it ; our reserve of infantry and cavalry must instantly advance, and attack the enemy. As he must naturally be much fatigued, and perhaps thrown into some confusion, whilst our troops are fresh and in the best order, it is most probable the enemy would be driven back.

This engagement between the enemy pressing in, and the reserve is so unequal, and the advantage so decidedly in favour of the latter, that unless our troops should be panick struck, the victory must be theirs. The greatest generals declare that in the defence of an intrenchment, they rely more on the reserve than on those who garrison the works.

§ 246. Sol-

§ 246.

Soldiers stationed behind a breastwork are in general timid, because they consider the works as a proof of their weakness, and the enemy's superiority; and as this prejudice is frequently the cause of an intrenchment's being so easily carried, we have the most important inducements to strive to do away this idea. It has therefore been frequently suggested that according to the custom of the Romans, camps should at all times be intrenched; by which means the soldiers would not regard such works as extraordinary. This proposal might probably be of service: at all events we should endeavour by just and reasonable arguments to deprive the soldiers of this notion. We should represent to them the great advantage they derive from the cover of the breastwork, whereas the enemy is totally exposed. We should point out the difficulties the enemy has to overcome, before he can approach the intrenchment; and that should he surmount these obstacles, and even cross the ditch and scale the work, they have still left the fire of their small arms quite close, and their bayonets to oppose him; and consequently the most favorable prospect of driving him back into the ditch. Lastly, we should explain, that even if a few of the enemy's troops should actually enter our lines, our reserve would soon repulse them.

§ 247. DE

§ 247.

DEFENCE OF REDOUBTS.

The mode of defence above described relates properly to a connected intrenchment, and I must therefore make some observations concerning the defence of a post consisting of detached redoubts.

The principle is the same. The redoubts are furnished with men and guns; the remainder of the infantry, together with the cavalry, forming a reserve behind the redoubts. However there is this difference, that in the present case sorties may very conveniently be made against the enemy's column of attack. If he advances towards a redoubt, a detachment is sent from our army to attack him, and may very likely drive him back. Our troops in this case should not pursue the enemy far, but retire quickly behind the redoubts. Should he make several unsuccessful assaults, it may perhaps be advantageous to advance with our whole army, and attack him.

Throughout this defence, a general is more master of his motions; but a post of this nature requires more troops than a connected intrenchment of the same length; for which reason it is at times very defective, notwithstanding the various other advantages attached to it.

CHAP.

CHAPTER VII.

ATTACK AND DEFENCE OF SMALL TOWNS SURROUNDED BY WALLS.

§ 248.

SURPRISE.

A SMALL town surrounded by a wall may be attacked in various manners. Sometimes it may be surprised, and an entrance gained by stratagem. This depends on our being able to get into the town entirely unobserved; or on any artifice to disarm the guard at one of the gates, and thus to enter. It may be effected by several schemes, of which I shall notice the following.

1. There are sometimes certain parts of the wall which are not particularly guarded, from a supposition that an attack there is impossible. If we can find an opportunity of approaching such a part, it is only necessary to send a detachment of men sufficient to overcome the nearest guard. They must climb the wall, and burst open the gate, upon which our troops enter the town.
2. We may endeavour to fix a petard secretly to the gate, and thereby force it open.
3. A detachment may march up to the gate, and strive to gain admission, by pretending

to be allies of the garrison. By speaking the same language as the enemy, and even wearing his uniform, he will perhaps be misled and open the gate.

4. If it is customary to allow the mails to enter the town by night, this pretext may answer to get the gate opened. For this purpose we should chuse the time that the post usually arrives, or intercept it, the more effectually to deceive the guard.

5. Confidential soldiers may be sent in disguise, or as deserters, and enter the service of the enemy. At a time agreed upon these soldiers must surprise the guard, and open the gate.

6. Lastly, we may endeavour to bring over to our interest, an officer of the garrison, and some soldiers with him. Our troops must seize the opportunity of their being upon guard, to surprise the place, which may thereby be easily entered.

§ 249.

ESCALADE.

Another manner of attacking a small town, is to scale the walls by means of ladders. If this can be done by surprise, there is nothing particular to be noticed. But if the enemy is aware of our intention, it is necessary that our detachment should be much stronger than the garrison; nor

should it be attempted unless the enemy is too weak to man the whole extent of the walls properly. In this case by fixing ladders on all sides, the enemy does not know, especially by night, where to apply the defence. In such circumstances, the attack must easily succeed, and therefore places in general which have a great circumference and a weak garrison, may be scaled in this manner.

§ 250.

ATTACK WITH CANNON.

The best mode of attacking a small town, is with artillery; by which means the gate, or part of the wall is battered until a large opening is formed: a column of troops then marches through this opening into the town, and attacks the garrison, in order to compel it to surrender. This is not, however very easily accomplished, for if the gate is well secured and rammed up, it would be difficult to batter it down; and if the walls are old and thick, we might probably fire a long time without even displacing a stone; and even should we effect a breach, it is not easy to drive away a garrison possessed of courage and firmness. It must also be expected, that during the time of making the breach, the garrison has been employed in throwing up an intrenchment to defend the entrance of the breach by a powerful fire, which may perhaps repulse our troops when they are arrived at the breach,

§ 251. BURN-

§ 251.

BURNING A TOWN.

A small town may also be forced to surrender by endeavouring to set fire to it. However as war is carried on, especially in modern times, only against soldiers, and not citizens; nothing but extreme necessity should induce us to adopt this mode of attack. By threatening the town with this cruel resource, we may probably attain our object, without putting it in execution. There may nevertheless be some cases, where the burning a whole town is no consideration to a general. For example, when the welfare of our army depends on the speedy possession of the place, which cannot be gained by any other means; or when we know that the inhabitants would thereby be seduced to oppose the garrison, and oblige the commandant to yield. In these and similar cases there need be no hesitation in sacrificing a whole town to the flames.

§ 252.

DEFENCE.

When an officer is entrusted with the defence of a small town, he ought to make numerous preparatory regulations.

1. Previous to being attacked, he should strive to improve the various defences as much as possible, according to the rules explained in the first part of this work.

2. A sufficient supply of provisions should be collected, that we may not be forced to surrender as soon as the enemy appears before the town, and cuts off all communication. This supply should be preserved in the most secure part of the town, and should not be used until we are actually blockaded, and can get no further assistance from without.
3. If there is reason to apprehend that in case of an attack, the inhabitants might turn against the garrison, they should be deprived of all arms, and forbid to be seen in the streets on the signal of alarm. On the contrary, they should be required to shew a light in every window, during an alarm by night.
4. Preparations should be made that any fire which might happen in the town at the time of attack, may be speedily extinguished.
5. Lastly, if the garrison is determined to defend itself to the last extremity, some particular part of the town, convenient for the purpose, should be fortified as a place of retreat, when the enemy gains an entrance any where.

§ 253.

DEFENCE AGAINST A SURPRISE.

To prevent a surprise, the whole garrison must observe an extreme and unremitted discipline. The
commandant

commandant should pay particular attention to the following circumstances.

1. He should have a perfect knowledge of the entire fortification of the town, that the guards and other detached posts may be properly disposed.
2. The rounds should be constantly going during the night; and every evening patrols of horse should be sent out on all the roads, that any march of the enemy towards the town may be instantaneously discovered.
3. Great precaution should be used respecting every person going in and out of the town; should any of them be in the least suspicious, they should be detained: and we should be particularly circumspect with regard to all deserters from the enemy, and all prisoners, who should be removed as soon as possible.
4. No gate should be opened at night, nor should any person be allowed even to approach the gates; and in the morning they should be opened with all possible precaution.
5. Lastly, the whole garrison should be constantly collected together, especially by night.

§ 254.

If notwithstanding all these precautions, the enemy can effect a surprise, and gain an entrance any where unobserved, the garrison should be previously

viously instructed to repair forthwith to the fortified post, allotted for a retreat. The officer must here examine the proper manner of proceeding. If the enemy's force in the town is not yet very strong, by hazarding an attack, we may probably repulse him quickly. But if this undertaking appears too difficult, he must remain in the post, and receive the enemy with firmness and valour.

§ 255.

AGAINST AN ESCALADE.

There need be but little apprehension of an escalade, provided the garrison is strong and properly on its guard against being surprised; but if the garrison is weak, and that the enemy can fix ladders almost in every part of the circumference of the wall, it must always be extremely difficult to provide against it. However the following measures for that purpose may be adopted.

1. The garrison should be properly divided, and each part of it shewn the particular post it is to defend.
2. The soldiers, besides their muskets, should be furnished with suitable weapons to defend themselves against an escalade. For example, with pikes, pitchforks, &c. to push down the ladders.
3. Chevaux-de-frise may be placed on the top of the wall, at those places which we cannot man; by which means the enemy is at all events

events delayed, and it affords us an opportunity of hastening towards him.

4. Each post should be supplied with great beams, or whole trunks of trees, which may be rolled down when the enemy's soldiers are upon the ladders.

5. If notwithstanding this resistance the enemy should scale the wall, the whole garrison must retire to the allotted post, and again defend itself in the best manner.

§ 256.

AGAINST AN ATTACK WITH CANNON.

If the enemy resolves to make a breach in the wall, by means of his artillery, and thereby to enter the town,

1. We must endeavour to create him as much trouble as possible in erecting his batteries. For this purpose whilst he is thus employed, we should keep a warm cannonade upon him; and according to circumstances, we may even make a sortie, to destroy the work he has already finished. As the enemy is obliged to throw up his breaching batteries pretty near the town, good marksmen with rifled-barrelled pieces, may be placed to fire at the batteries, and endeavour in particular to kill the artillerymen.

2. As soon as it is ascertained where the breach will be made, the garrison must intrench itself

itself behind that part of the work, by putting the adjoining houses into a state of defence, and throwing traverses across the streets. Behind these traverses, one or two guns may be placed, so as to enfilade the opening through which the enemy must enter. As soon as he arrives there, he must be received with a brisk fire of grape shot. At the same time an incessant fire of musketry must be maintained from the houses and traverses.

3. Lastly, if the garrison can no longer preserve this station, it must withdraw to the post allotted for that purpose; and must either defend itself to the last man, or by capitulating, endeavour to obtain the most advantageous terms.

FINIS.



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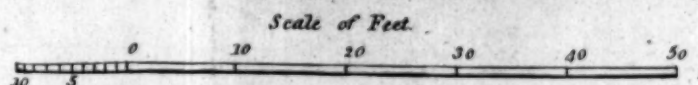
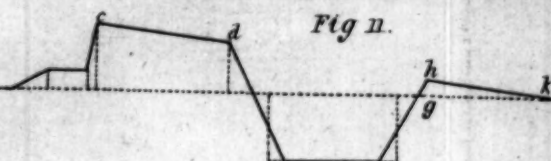
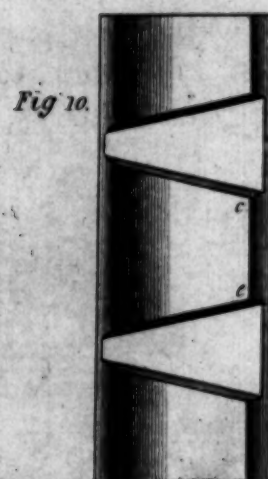
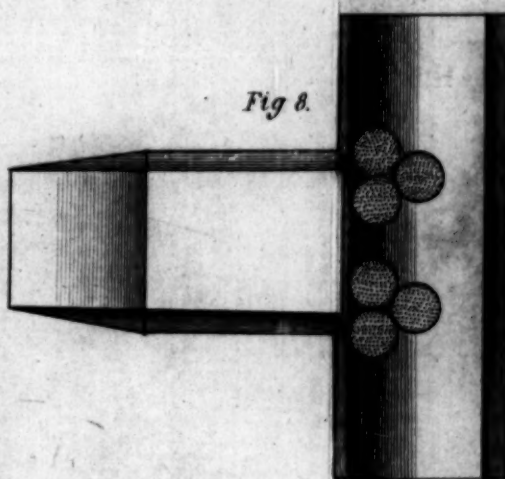
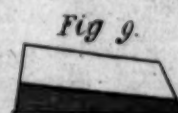
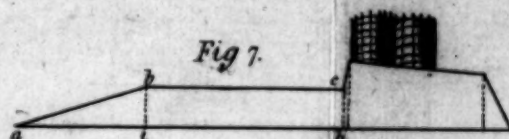
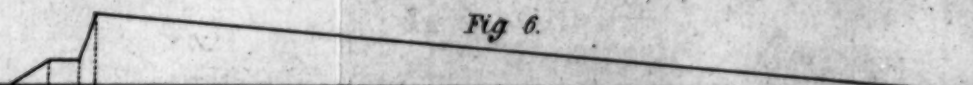
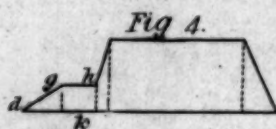
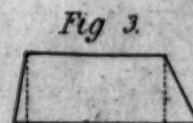
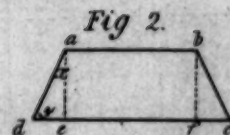
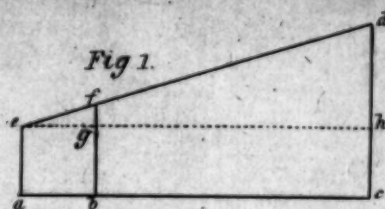


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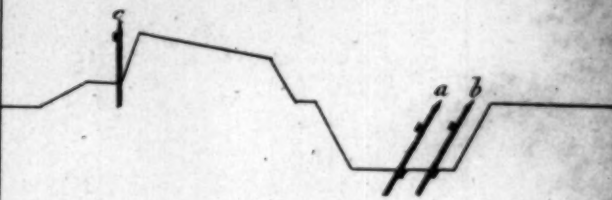


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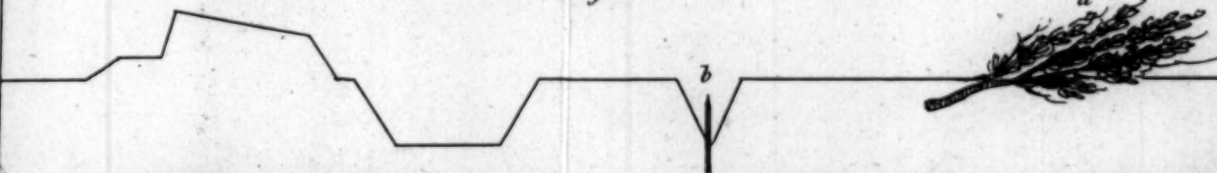
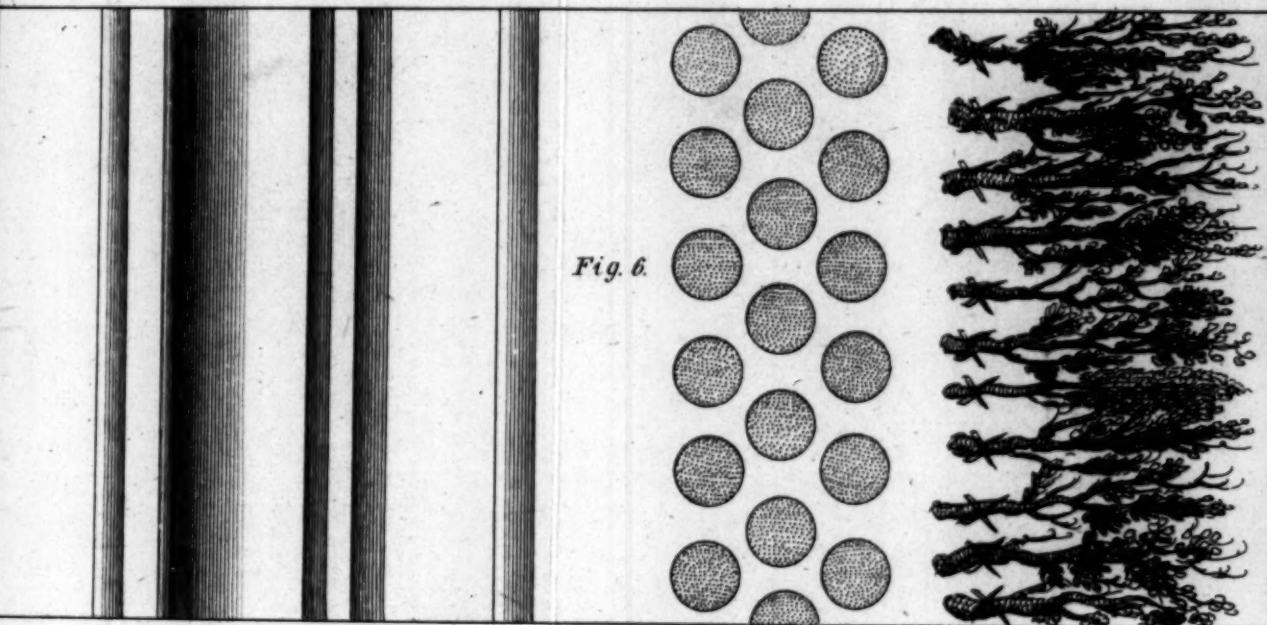
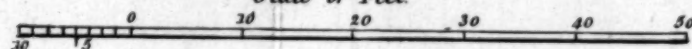


Fig. 6.



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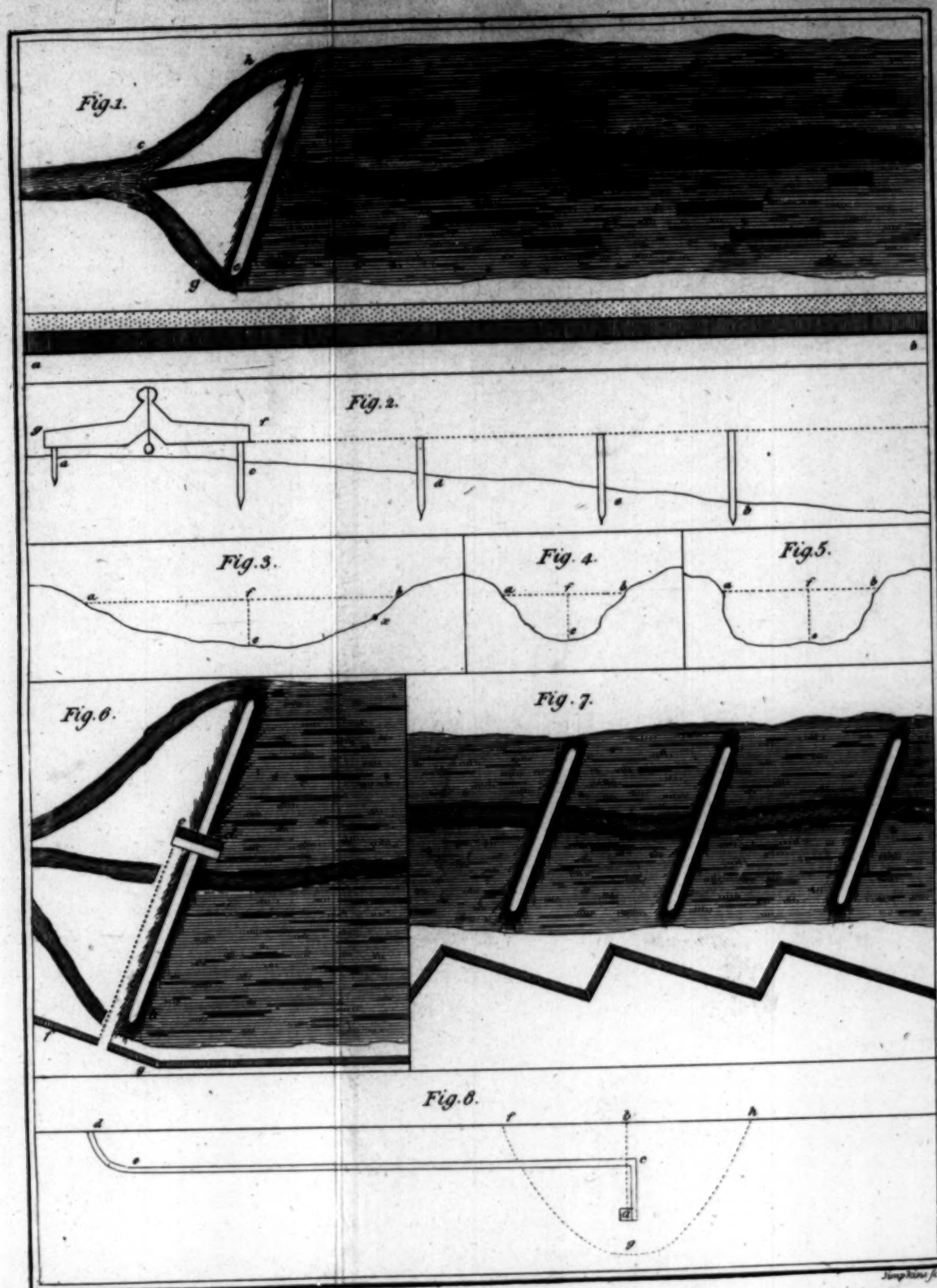


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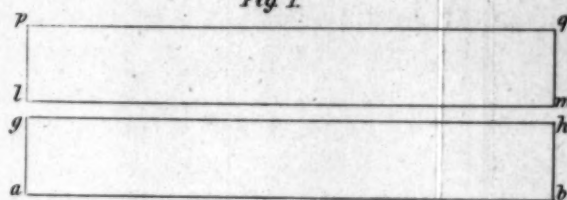


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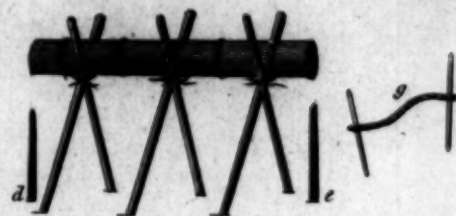


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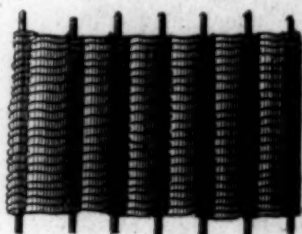


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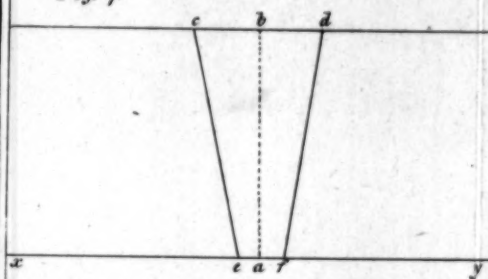


Fig. 8.



Fig. 9.



Fig. 10.

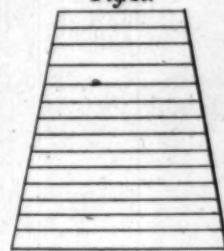


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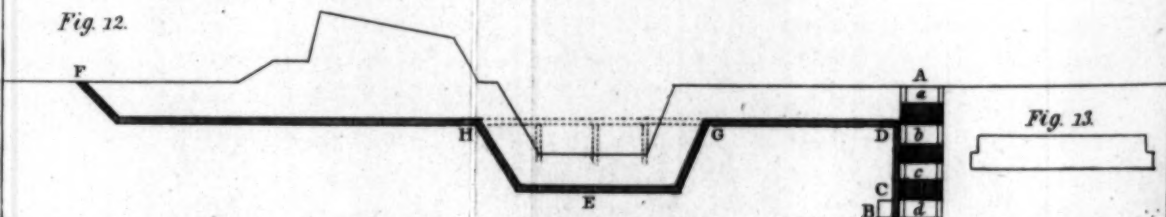


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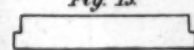


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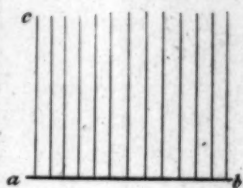


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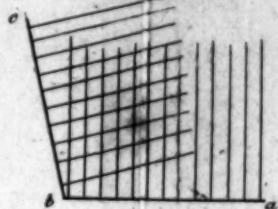


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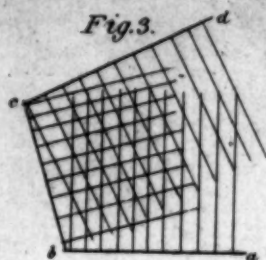


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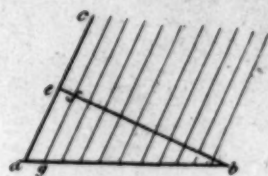


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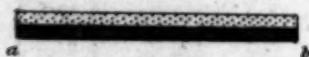


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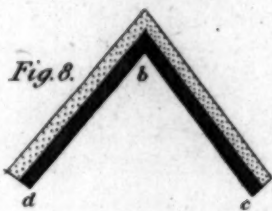


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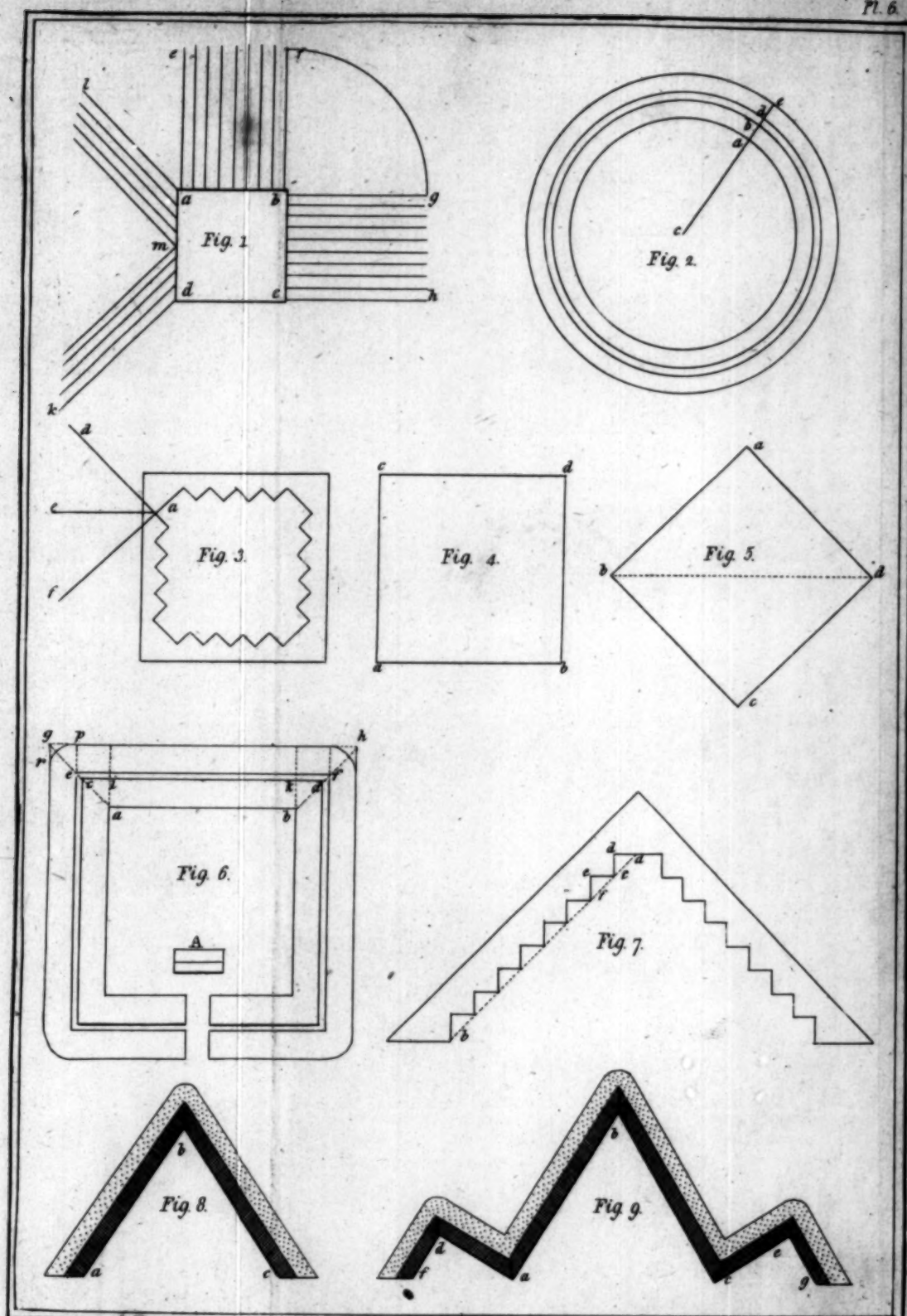


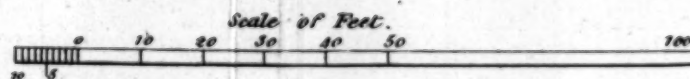
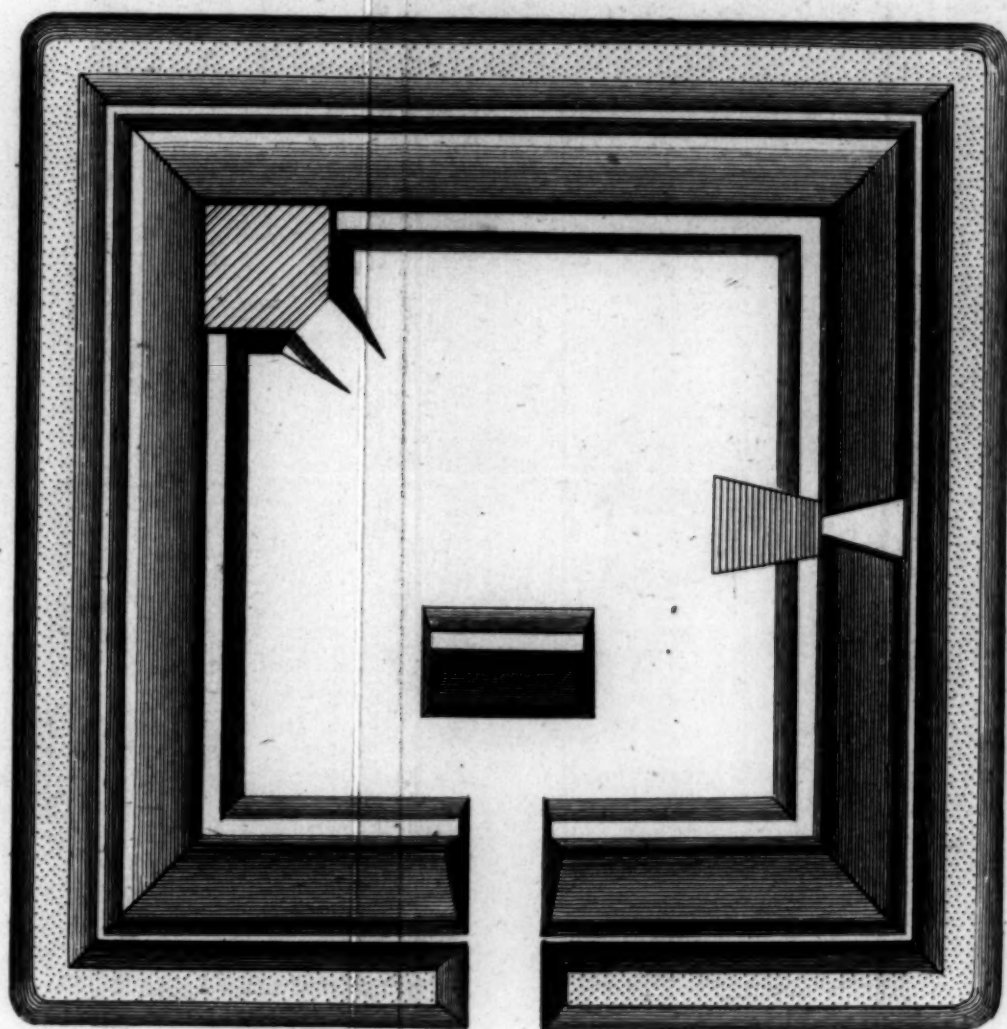
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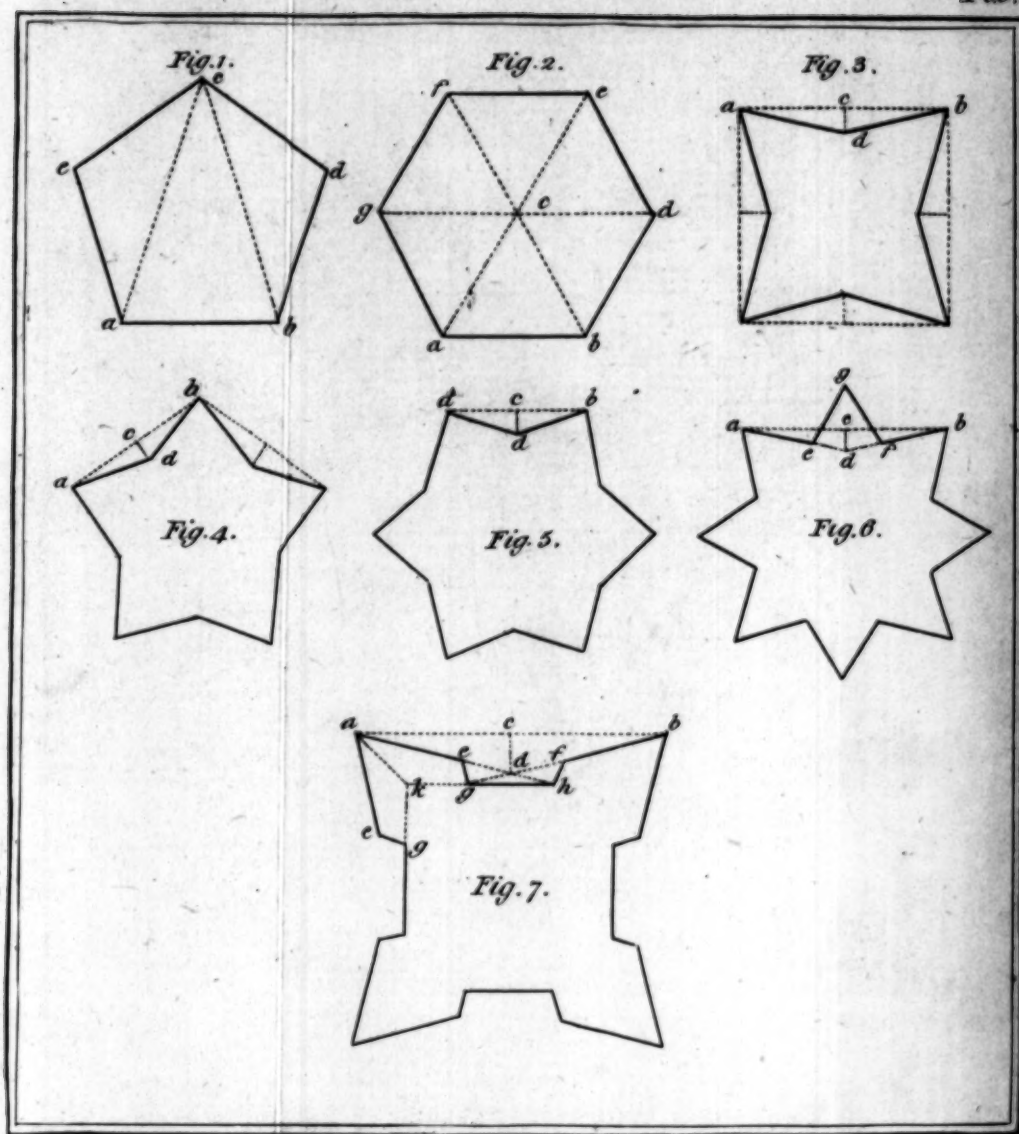


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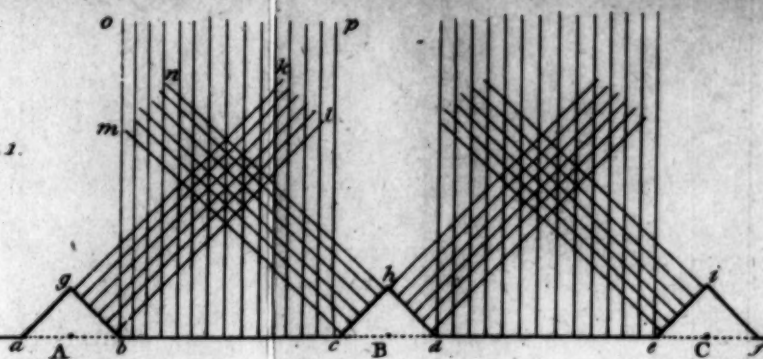


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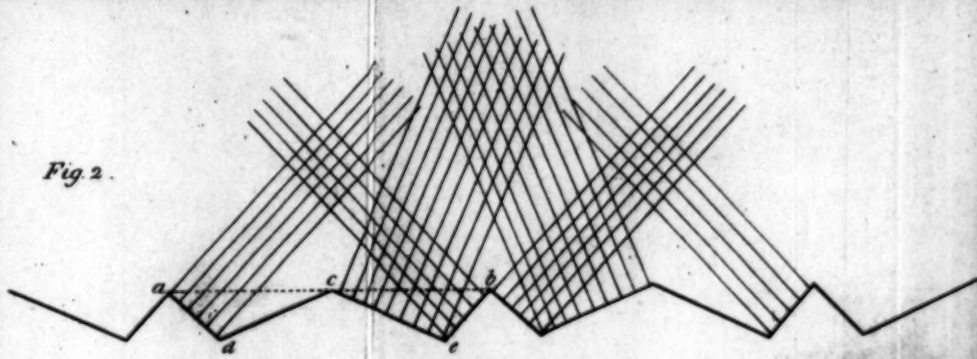
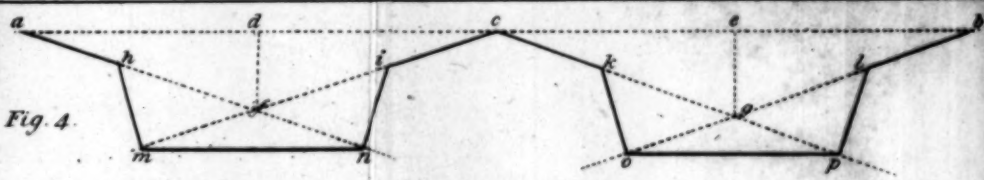


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Fig. 4.



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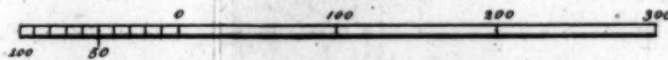


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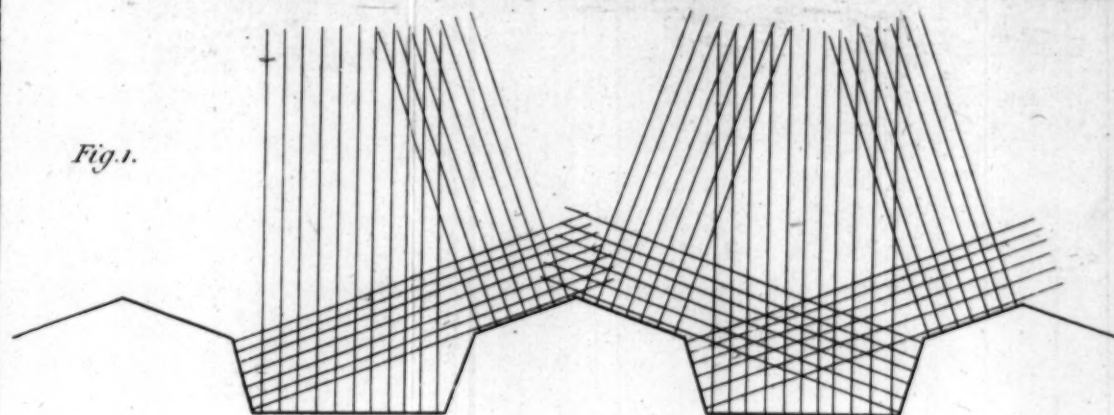


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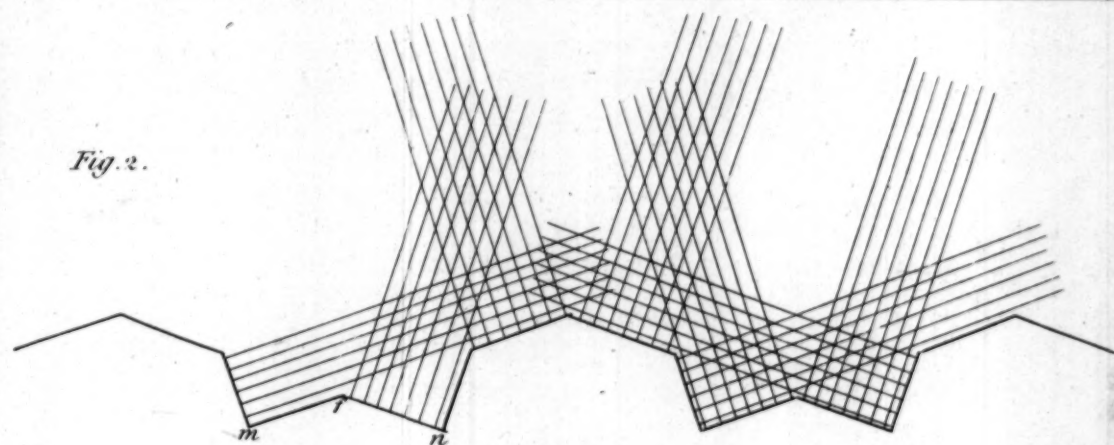


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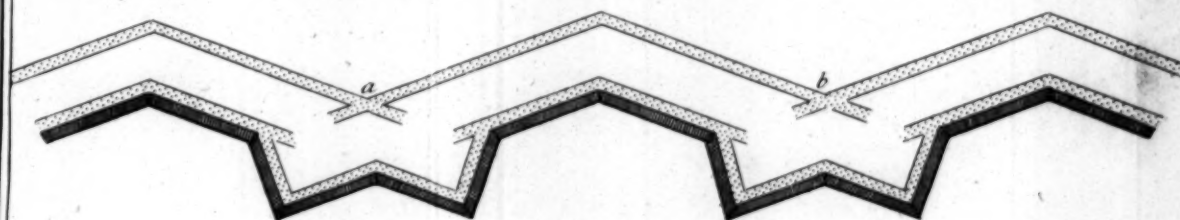


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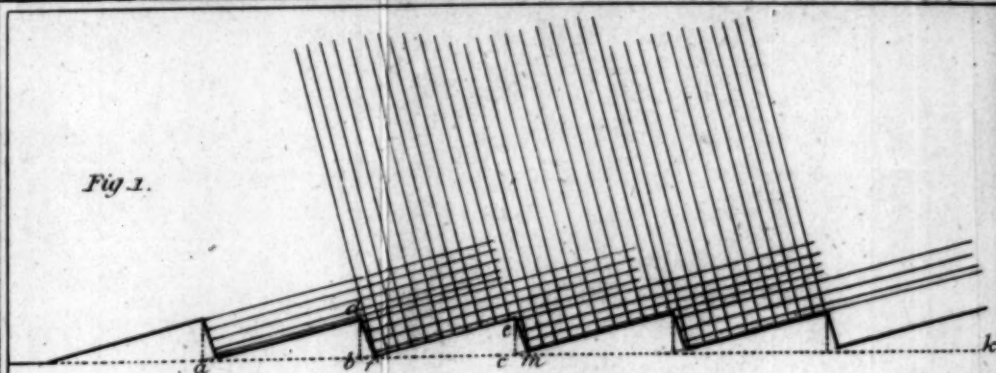


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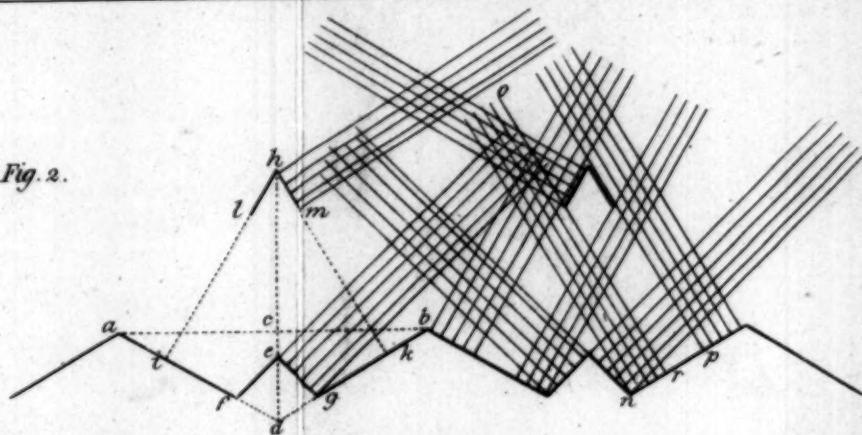


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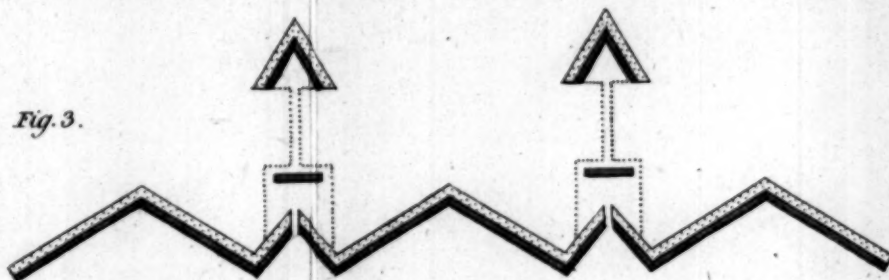


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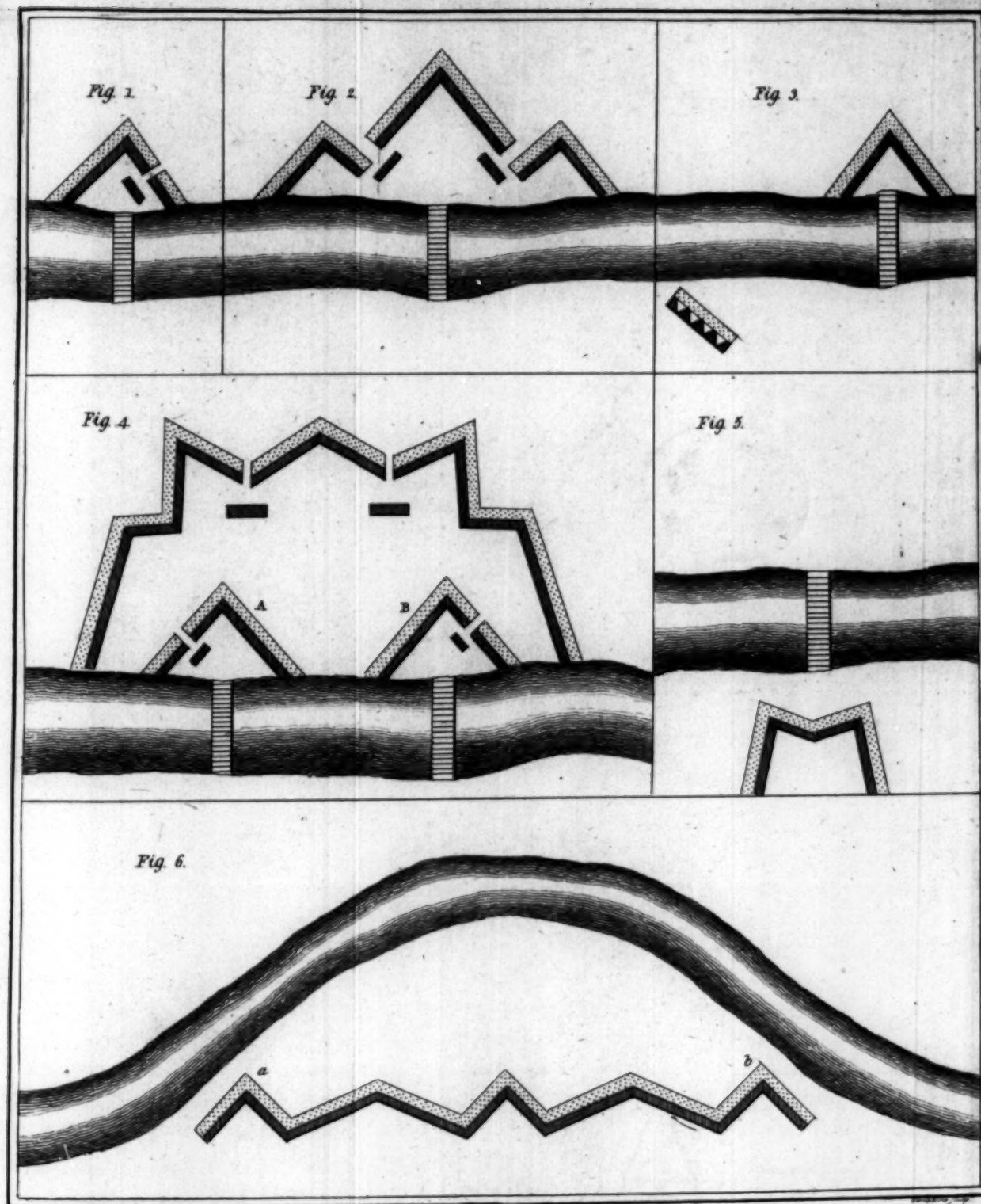


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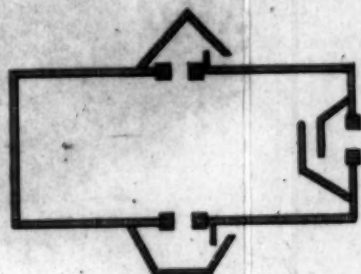


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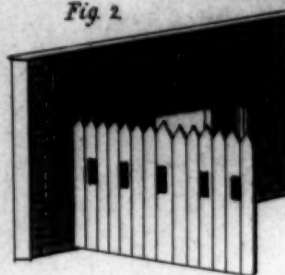


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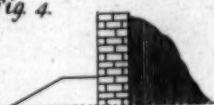


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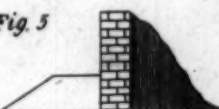


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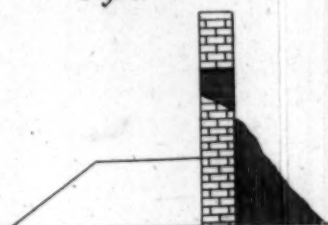


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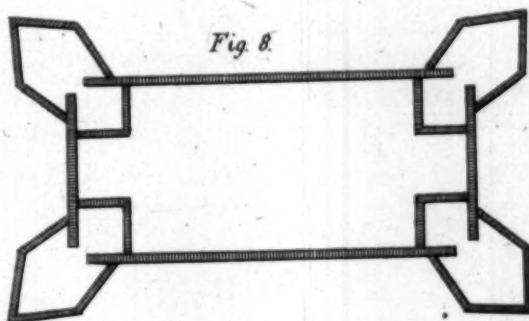


Fig. 9.

